

**AMC PAMPHLET**

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# **PROCUREMENT**

## **SHOULD - COST ANALYSIS GUIDE**

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WASHINGTON, DC 20315

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No. 715-7\*

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PROCUREMENT  
SHOULD-COST GUIDE

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\*This pamphlet supersedes AMCP 715-7, 17 November 1970.

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FOREWORD

This pamphlet supersedes all previous editions of AMCP 715-7. In addition to a general editing, the coverage on team size and composition, planning and managing the analysis, and elements and techniques of analysis have been expanded or entirely rewritten. A completely new area has been added covering Management Improvement Programs (also known as Goal Achievement Programs). Where appropriate, the reader is referred to publications in the Should Cost library for specific guidance or data.

Perhaps most importantly, the guidebook has been updated to include the lessons learned since the previous edition, both through on-the-job experience and scientific research on subjects such as team size and composition, the selection and motivation of team members, team organization, management improvement programs, and others.

This pamphlet applies to Headquarters, US Army Materiel Command (AMC), and to AMC major subordinate commands. This guidebook is intended both for training and for operational use in Should-Cost Analyses, and concentrates on the production contract environment, where Should-Cost is most often applied.

This pamphlet will be kept up-to-date and maintained by the US Army Materiel Command (US Army Procurement Research Office).

Note. The Should-Cost Analysis Guide is advisory in nature, and is not directive. US Army Materiel Command Should-Cost activities are governed by AMCR 715-92, Should-Cost Analysis. All actions taken should be in accordance with this regulation. In the event of any conflicts between this guidebook and the regulation, the regulation will prevail.

THE SHOULD-COST CENTER

The US Army Procurement Research Office, Institute of Logistics Research, US Army Logistics Management Center, Fort Lee, Virginia 23801, has been designated as the AMC Should-Cost Center to perform the following functions:

1. Research concerning the use and expansion of Should-Cost.
2. Establish and maintain a bibliography and library of reference material.
3. Provide consultant services on an "as required" basis to assist field teams in planning or with specific problems. Such assistance is presently available in contract law, pricing, mathematics, statistics and statistical techniques, computer applications, industrial engineering and economics.

CHAPTER 1

INTRODUCTION AND BACKGROUND OF SHOULD-COST

I. The Need to Improve Defense Procurement

1. Large overruns and cost growth on many military programs in recent years have aroused severe criticism in the public press and have become topics of continued debate in the Congress. Meanwhile, the growing demand for public funds to support other Government needs is resulting in the availability of less money for Defense programs--while inflation and expanding technology are increasing the costs of Defense hardware.

2. Because of these factors, the procurement environment, the atmosphere in which we acquire our weapons and services, is significantly changed. There is less money to spend and hence it must be spent more carefully and wisely. All agencies of the Government must react to this situation by improving their stewardship of public funds.

II. What is Should-Cost?

1. The term Should-Cost describes an approach to cost analysis through fully coordinated efforts of a team of Government specialists in engineering, pricing, audit, procurement, and management. The specialists review in detail the contractor's engineering and manufacturing operations, accounting procedures, cost estimating systems, purchasing procedures, make-or-buy decisions, organizational structure, and any other elements of cost and management control required for contract performance. The analysis is used to identify uneconomical or

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inefficient practices in the contractor's operation, and to formulate the Government's negotiation position, on the basis of the team's estimate of what the contract should cost to perform, based on reasonably achievable economies and efficiencies.

2. Should-Cost differs from the traditional approach to cost analysis principally in two respects: the depth of the analysis; and the extent to which the Government challenges inefficiencies in the contractor's operation. (Traditional analysis effort is based largely on projections of historical cost data. When past operations have been inefficient, such projections of cost data thereby have an automatic "built-in" factor to cover the cost of continued inefficiency.) The following statement, extracted from Congressional testimony ("Hearings Before a Subcommittee of the Committee on Government Operations," House of Representatives, 91st Congress, 1st Session on H.R. 474 - Government Procurement and Contracting [Part 5]), written to a contractor, epitomizes the Should-Cost concept:

...we wish to make very clear indeed the precise nature and application of this method of pricing... During our team briefings at the plant...we were informed by (your) personnel that, among other things, the plant is operating at only 80% efficiency, you have a labor turnover of alarming proportions, and you do not validate labor standards and allowances on any regular basis, etc.

That is why Government personnel are presently in your plant conducting an in-depth analysis of those elements of your operation which we consider necessary to ascertain what the reasonable cost to the Government...should be...

Thus, the negotiation with you will be conducted, not on the basis of (your actual cost of production),

but on the basis of what production...should cost if your plant were being operated efficiently. In other words, this approach may result in a decision by the Government not to accept the costs of admitted or indicated inefficiencies irrespective of whether such costs are actually incurred. The should cost method...must not be construed as an attempt on the part of the Government to tell a contractor how to conduct his operation--if, for example, the contractor wishes to conduct a patently inefficient operation, with excess indirect employees, poor estimating, labor that consistently fails to meet standards, lack of proper competitive subcontracting, abnormal spoilage and rework, etc., that is his business. It is the Government's business, however, not to pay taxpayer's money for demonstrable inefficiencies in the manufacturing process of a sole source supplier, regardless of the quality of the ultimate product.

We respectfully submit that inherent in this should cost approach is a very real stimulus to bring about vigorous management at all levels and meaningful employee motivation with resultant economy and efficiency. Moreover, it is sincerely suggested that our approach will, in the long run, prove mutually beneficial to your company and the Government, with more profit to you because of less costs and lower total prices to us.

3. In order to contrast the traditional (or "will cost") approach with the previous statement, the following quotation from a traditional pricing memorandum was also included in the Congressional testimony:

The price analyst considers this a management function, and to say that indirect people are excess because the present ratio of indirect to direct is unfavorable when compared to other periods of time is not reasonable. The contractor is entitled to his costs of operating the facility, and if we think his costs are too high, we should seek a cheaper facility, but since we have engaged him, he is entitled to his costs.

III. Relationship of Should-Cost to the Armed Services Procurement Regulation (ASPR)

1. ASPR 3-807.2(c) directs cost analysis toward forming an opinion of "...what performance should cost, assuming reasonable efficiency and economy." A "realistic price" has been defined as "...one that is influenced strongly by the prospect of what it should cost to perform if the contractor operates with reasonable economy and efficiency."
2. In following the "will cost" approach to negotiations--accepting the contractor's cost history as a baseline for projections--there is an implicit acceptance of past uneconomical or inefficient practices. Any base for projecting future costs which has been built on poor practices tends to perpetuate them, rather than to eliminate them.
3. The Should-Cost approach, on the other hand, tends to achieve the ASPR objective--that of determining "--what performance of the contract should cost, assuming reasonable economy and efficiency." This is accomplished by first conducting an in-depth analysis of a contractor's management, cost estimating, and production practices aimed at the identification and quantification of uneconomical or inefficient practices. From a baseline developed by first eliminating these costs, projections are then made by generally accepted methods to arrive at what future requirements should cost.
4. It is not the intent of the Government, through the Should-Cost approach, to direct or control the contractor's management or

production effort, but rather to foster improved practices through the vehicle of realistically established and attainable contract prices.

**IV. Objectives of Should-Cost**

Should-Cost analyses are performed principally to accomplish the following important objectives:

1. To facilitate the negotiation of realistic contract prices.
2. To bring about both short-range and long-range improvements in the efficiency and economy of contractor's operations.

**V. Background**

1. The beginning of Should-Cost

a. Civilian applications

Should-Cost began in the civilian economy. A large, nation-wide consumer goods chain has used the technique for many years on the suppliers of its appliances, hard goods, and other items. The application has been successful in obtaining consistently low prices from the supplying companies. It has encouraged the suppliers to constantly search for more efficient ways to manufacture their products in order to retain the sizeable orders of the retail chain. The buying power of the chain is sufficiently large to permit it to insist on the use of Should-Cost with its suppliers.

b. Military applications

(1) In late 1967 the Department of Defense was concerned over the high price of the F-30 jet engine (for the F-111B).

Under the leadership of the Chief of Naval Procurement, Clearance Division, a DOD team undertook the assignment of the first Government Should-Cost study. The results were significant and demonstrated the usefulness of the technique both for lowering costs on the instant contract, and for accomplishing long range improvements in contractor operations. [For further information on this case, see Part 5 of the House of Representatives (Holified Committee) hearings on H. R. 474.]

(2) The Army, recognizing the value of Should-Cost, has implemented a program to aggressively pursue and expand its use on major procurements. The Army has successfully completed Should-Cost analyses for major weapon systems and commodities. The results prove that significant cost savings and long term management improvements can be achieved through Should-Cost.

c. Army Plans for Future Should-Cost Application

(1) In testimony before the Subcommittee on Economy in Government of the Joint Economic Committee of the Congress, the Assistant Secretary of the Army (Installations and Logistics) made the following commitment:

This technique (Should-Cost) will be used in major procurements when genuine price competition is not existent and when it is determined that such an in-depth analysis is necessary in preparing for contract negotiations. The determination will be based on an evaluation of the contractor's cost history, preponderance of Government business, dollar value of the procurement under review and the amount of other Government contracts to be awarded to the contractor concerned. In advertised or negotiated

procurements in which genuine competition exists, it is generally assumed that the objectives of the Should-Cost philosophy are attained by competitive forces of the market place.

(2) As indicated in the Secretary's testimony, the Army is applying the Should-Cost technique to selected major noncompetitive procurements.

(3) Thus far in the development and implementation of Should-Cost, its use has been directed primarily toward repeat production buys having little or no concurrent development effort. This has been true principally because such contracts are usually of large dollar value, and the comparatively "fixed" design status of such items makes major changes in production processes unlikely. Also, the Army's analytical skills in pricing tend to be concentrated in the production environment. Nevertheless, the returns achieved in production Should-Cost efforts are causing the Army to consider applying Should-Cost further "upstream." At this writing, approval has been given for Army procuring agencies to nominate carefully selected research and development contracts for Should-Cost analysis.

... Scope of the Should-Cost Guide

1. Although this Guide may be helpful in applying Should-Cost to research and development and other special situations, it is directed primarily toward major production contracts.
  
2. Neither the Should-Cost concept nor the Guide comprises an all-purpose "cookbook" approach or panacea. Only the basic principles

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and techniques are covered, and examples are furnished illustrating how to attack commonly found situations. The reader must realize that the Guide cannot foresee all possible combinations of contract circumstances.

3. In conducting its work, the team will constantly have to improvise, to apply its combined ingenuity to develop solutions to specific problems. The Guide serves only as a baseline, a basic tool kit for the analyst. It does not rule out the development and use of "fields mods" that best fit the individual situations.

CHAPTER 2  
SELECTION AND NOTIFICATION OF  
CONTRACTORS FOR SHOULD-COST ANALYSIS

I. Selecting a Contract for Analysis

1. In selecting a contract for analysis, there are certain factors that are so important as to constitute "Go/No Go" considerations. They are:

a. Lack of Adequate Price Competition

It is generally conceded that the existence of true price competition will stimulate contractors to apply effective cost control methods, thereby obviating the need for Should-Cost analysis. Based on the meaning of "adequate price competition," as defined in ASPR 3-807.1(b), it can be said that there is a lack of adequate price competition whenever it is necessary to employ cost analysis, to any degree, to establish the reasonableness of an offeror's price. (Cost analysis is the review and evaluation of a contractor's cost or pricing data and of the factors applied in projecting this data to the estimated costs, whereas price analysis is the process of examining and evaluating a prospective contractor's price without evaluation of the separate cost elements and proposed profit.)

b. Sufficient time for the analysis

Approximately 15-20 weeks are usually required to complete a Should-Cost analysis from the time of contract/contractor selection to commencement of negotiations. If circumstances preclude the team's having sufficient time to do a quality job, the analysis should not

be undertaken. It should be noted, however, that letter contracts, extended schedules or other means may be justified in some instances in order to perform the analysis.

c. Procurement of significant dollar value

This factor must be considered along with such others as the cost of the analysis, probable returns, etc. It is difficult to assign a strict "floor," under which Should-Cost would never be appropriate. AMC Regulation 715-92, however, establishes policy guidelines in this respect.

d. Availability of personnel with required special skills

In some analyses, there may be requirements for special skills in order to evaluate key elements. Examples of such skills may be certain subspecialties of chemical engineering, aeronautical engineering, computer systems design, and others. If people with such skill are not available to serve as team members, consideration should be given to using consultants from the Army Procurement Research Office, other Government activities, or consultant firms.

e. Task sufficiently well known and defined

This factor may be viewed best by answering the questions: "Is the work sufficiently well defined, in a technical sense, to be effectively analyzed?", and "will the Government be able to derive sufficient confidence from the resulting estimates to negotiate effectively?"

2. Only if the above "Go/No Go" considerations may all be answered affirmatively, should a contract be regarded as a potential candidate for Should-Cost. Clearly, there may be several such candidates; the question then arises as to which candidate will provide the optimum return (in both long and short range benefits) for the investment of the Should-Cost effort. The actual selection from among the possible candidates should generally be based on a trade-off analysis of the following factors:

- a. Potential for significant follow-on business.
- b. Known or suspected specific problems which the analysis could help remedy or improve.
- c. History of rising costs, or other evidence of improvements needed in cost controls.
- d. Probability and desirability of shifting cost risk to the contractor by improving contract type and/or incentive sharing arrangements.
- e. Preponderance of Government business.
- f. Probability that benefits of Should-Cost improvements will extend into other contracts or subsequent efforts.
- g. Existence of a reasonable base of historical data to facilitate the Should-Cost analysis.
- h. Manufacturing methods and environment reasonably stable and not likely to change.

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- i. Program not subject to excessive technical, quantity or schedule change.
  - j. Lack of confidence in current cost estimates.
  - k. Reasonable strength inherent in the Government's bargaining position.
  - l. Potential for significant improvements in the efficiency and economy of the contractor's operations.
  - m. Other factors, as appropriate.
3. In reviewing a contract for potential Should-Cost candidacy, the foregoing considerations are intended to help determine whether the analysis is necessary and worthwhile; whether it is operationally feasible; whether the results are likely to be successfully negotiated; and finally, whether the contract being considered is the optimum candidate for analysis, among all of those meeting the basic "Go/No Go" considerations. It must be remembered that a Should-Cost analysis is expensive, and to squander the effort and expense on a situation not likely to be successful would be contrary to the concept behind Should-Cost.

## II. Notification of the Contractor

1. The contractor whose operations and proposal will be evaluated in the Should-Cost study should be notified by a letter from the commanding general of the procuring commodity command. The letter

should reach the contractor at least 30 days prior to the start of the on-site work by the team. Copies of the letter should be sent to:

- a. Headquarters, AMC (Directorate for Requirements and Procurement).
  - b. Commander of the cognizant plant representative office or DCAS organization.
  - c. Head of the appropriate audit agency office.
  - d. Army Procurement Research Office.
2. The letter should cover the following topics:
- a. The purpose of the Should-Cost study.
  - b. The proposal that will be evaluated, noting both the RFP/RFQ involved and the specific contractor response.
  - c. The arrival date for the advance team.
  - d. The arrival date for the total team.
  - e. The approximate duration of the on-site work.
  - f. The approximate office accommodations required.
- g. The names of the team chief, deputy and operations officer.
- h. The individual(s) to whom the contractor can direct questions regarding the study until the team arrives.

CHAPTER 3

THE SELECTION, ORGANIZATION AND ADMINISTRATION OF A SHOULD-COST TEAM

I. The Importance of Quality

1. Since Should-Cost is clearly not "business as usual," it is generally agreed that the most critical single task in an analysis is the selection of the team. This is true because the team managers and analysts are taken away from their homes, families, and normal working environment for extended periods. They are called upon to work long hours; often six and sometimes seven days per week at maximum productivity and under great schedule pressure. They are often working in an adversary relationship with the contractor. Experience has shown that many potential team members are either unable or unwilling to perform satisfactorily in these circumstances.

2. In the past, it has been necessary to send team members home sometimes because of illness or family emergency, but more often because of lack of motivation or technical ability or inability to perform in the Should-Cost environment. In some other cases, members of barely acceptable productivity have been retained on the teams simply because replacements were unavailable or because their shortcomings were not recognized until too late in the analysis. There have been instances in which team members have been appointed without ever having been told what was the job at hand, how long it would take, or consulted on their attitude toward serving on a team. Such appointments rarely work out well, and often result in counter-productive

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hostility and resentment within the team. In almost every case investigated, these types of problems could have been anticipated and thereby avoided by providing the team's manager an opportunity to interview the members before the selections were made. It is strongly recommended that the team chief and his subteam chiefs thoroughly satisfy themselves as to each member's ability and motivation by carefully reviewing their qualifications and conducting personal interviews.

3. In order to insure that the importance of team selection is fully understood, the following quotation from one former team chief is utilized (interviews with other team chiefs have confirmed the observation):

I sincerely believe that our team could have done a better job with only half the people we had, provided that we had known in advance which half to start with.

## II. Team Member Qualifications

1. All the members of a Should-Cost team must already be fully qualified in their specialties. Although Should-Cost training programs are available, they are designed to help motivate team members and to show how their skills may be best applied in the Should-Cost environment. They are not intended to raise an individual's level of technical competence. Similarly, a Should-Cost team does not have the luxuries of time or resources needed to be a training ground.

2. In addition to their technical skills, the members must have proven ability to express themselves clearly and concisely both orally and in writing. Several teams have had genuinely serious problems in putting together a report that can be read and understood for use in negotiation.

3. To the extent possible, the team members should have sufficiently broad backgrounds of education and experience to enable them to communicate effectively with specialists in other disciplines. This will be helpful during both the analytical effort and the report writing stages.

4. Perhaps the most important single requirement for a team member is that he be highly and personally motivated. He should thoroughly understand the Should Cost concept, and believe in its value; he should have confidence in his own ability and in his team-mates and leaders; he must recognize that a maximum effort on his part will contribute significantly to the team's success. Above all, the members must be personally dedicated to the team's success. A true "team spirit" is essential in obtaining top quality work for long hours over an extended period of time, especially when the members are away from their homes and families. Once a team has been formed, it is the team chief's responsibility to establish and maintain team spirit and motivation.

5. Another vital attribute of the team member is his attitude toward the contractor. All team members should be unemotionally critical of the contractor and his operation. If the team member is not, then the chances are that he will accept superficial justifications and explanations when deeper analysis is warranted. He

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must be critical in his attitude and in his questioning and probing. It is this objective and searching approach that helps to insure that all the facts are disclosed so that a proper judgment may be made. In a Should-Cost study it can be assumed that the contractor will readily disclose information favorable to his negotiation objective. Rarely will he voluntarily divulge information unfavorable to himself unless there is a possibility that he could be accused of purposefully withholding information. It is therefore necessary that Should-Cost team members be critically inquisitive in order to provide a proper counter-balance to the contractor's tendency of providing only favorable data.

6. The members of the Should-Cost team should be selected because of intelligence, motivation, and professional abilities. They are expected to conduct themselves in a professional manner during the course of the study and maintain objectivity, criticality, "tough mindedness," and discretion.

**III. Team Size and Composition**

1. As has already been stated, a Should-Cost team is comprised of specialists in many different skills. The proper number of team members and the skill mix varies among analyses.

2. Experience has shown that there are two basic rules concerning the selection of a team of the proper size and composition:

a. The team's size and composition must be related directly to the task at hand. In other words, the team should be fitted to the

specific job, rather than attempting to establish arbitrary guidelines based on what was "right" for other analyses.

b. The second rule appears to follow almost automatically from the first, but bears emphasis. Whoever establishes the team's size and composition and makes the selections of the members must have a clear understanding of the task to be performed. This means that these decisions cannot be made "from an armchair," but require a genuinely thoughtful evaluation of the contract to be performed, the contractor and his methods of operation, the analytical tasks and subtasks, and the numbers and skills of the people required to complete the job successfully.

3. The most promising approach yet found for establishing optimum team size and composition is to use an advance team. This group, usually comprised of the team chief, deputy chief, operations officer, and subteam chiefs, spends three to five days at the contractor's facility, to accomplish the following:

- a. Begin the team planning, especially pertaining to the numbers and skills of people required for the analysis. (The importance of this task cannot be overstressed - it is a "must!")
- b. Familiarize themselves with the contract task and the contractor's operations.
- c. Notify the contractor of the necessary administrative requirements, required tours and briefings for the team and other related information, and give him a general briefing on Should-Cost.

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d. See Chapter 6 for more detailed considerations for the advance team.

4. Because the team chief has the ultimate responsibility for the team's success or failure, he should be given as much freedom as reasonably possible in making these decisions.

#### IV. Organization of the Should-Cost Team

The organization of the team should be simple, direct and straightforward. It should be sufficiently flexible to permit adaptation to changing day-to-day needs without disrupting the team's operational effectiveness. The most commonly used form of organization is set up along functional lines, as illustrated in Figure 3-1. Another form, shown in Figure 3-2 has also been used; it is more "project oriented" than the functional organization, and is built around the Work Breakdown Structure (WBS). The latter form was used to Should-Cost a major system subcontractor, and was developed in order to facilitate performing the Should-Cost analysis simultaneously with the technical analysis. In the analysis, Groups 1 through 4 concentrated their efforts principally on the technical analysis. At the time of this writing, the analysis has not yet been completed, and it is too early to determine "Lessons Learned" on the WBS form of organization. It is recommended that teams considering the use of WBS contact the Should-Cost Center for up-to-date advice as early as possible in the Should-Cost cycle.

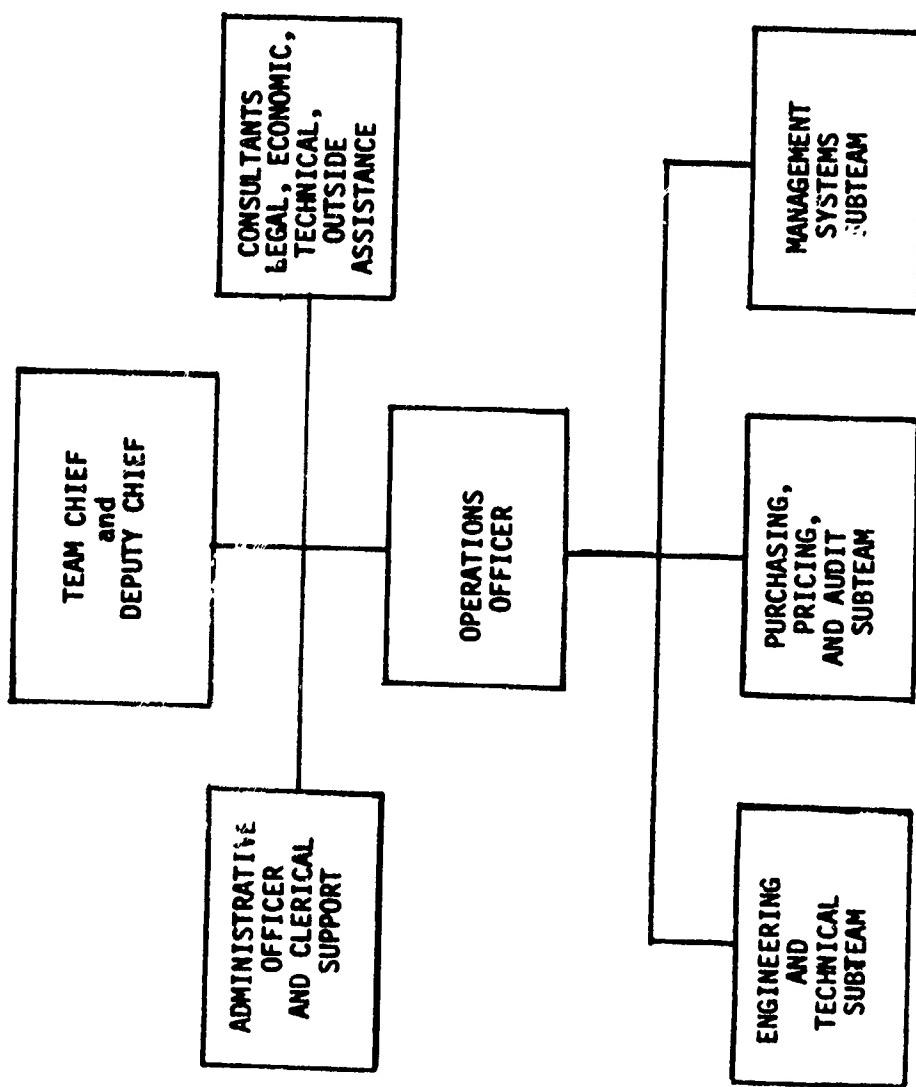


FIGURE 3-1  
TYPICAL FUNCTIONAL SHOULD-COST TEAM ORGANIZATION

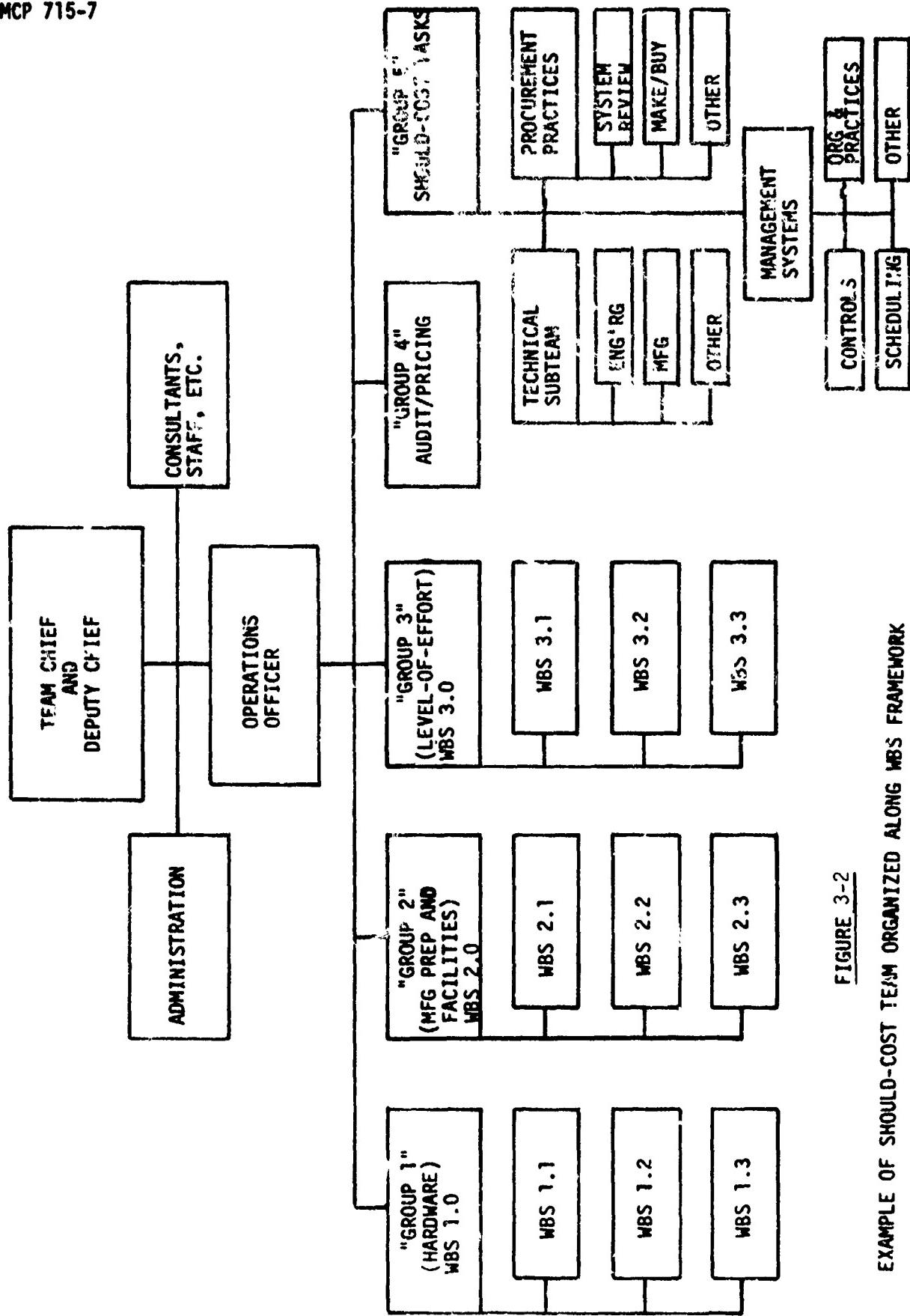


FIGURE 3-2  
EXAMPLE OF SHOULD-COST TEAM ORGANIZED ALONG WBS FRAMEWORK

V. Administrative Requirements

1. The normal Should-Cost study is made under adverse conditions.

The team members will be away from home, working long hours under trying conditions. The team is faced with doing a large amount of work in a short period of time. In these situations, attention to the simplest administrative details can make a great difference in the morale and productivity of the team. What may have been a minor inconvenience at home often can become a real "line-stopper" in the field.

2. The following requirements exist during the on-site phase, at the contractor's plant. They do not constitute a complete checklist, but represent the principal areas that must be considered.

a. Quarters

The team members should be housed within reasonably convenient proximity to each other and to the plant. Preferably the accommodations will be located near a variety of eating places. If possible, choose a hotel or motel that has meeting rooms available for discussions of sensitive information.

b. Transportation

(1) Some type of automobile rentals may be required on individual team member's orders. The administrative officer should coordinate the team's requirements to make certain there are sufficient vehicles authorized.

(2) In some cases, it will be advantageous to the Government to authorize some of the team members to travel by their own private automobiles. This will help to significantly reduce the cost of car rentals.

(3) It may be possible to have staff cars and drivers or a bus and driver assigned for the team's use. If in so doing the rental car expense can be minimized, the possibility should be explored. If parking facilities are limited, this approach may save some strain on available space. Such an arrangement may not work satisfactorily, however, if some of the members work additional hours when the driver is not available. The team's working hours should not be curtailed or adjusted to fit those of the driver.

c. Postal Arrangements

The team's incoming and outgoing official mail must not be handled through the regular contractor's system. Probably the best method of receiving mail is through a rental box in a nearby Post Office; or through the resident Government audit or contract administration office, provided their mail is not received through the regular contractor's system. The exact method should be left to the discretion of the team chief.

d. Office Accommodations Useful in the Plant.

- (1) Private office for the team chief.
- (2) Private office for the deputy chief and the operations officer. If space is scarce, these individuals can share the same office.

(3) Working space for each of the subteams. An allowance of 50 square feet per man is about the minimum. It may be necessary to house all the subteams in one large room. This is not conducive to productive activity and should be avoided if possible.

(4) Conference room.

(5) Administrative section should have a work area separate from the subteams so that the noise of the typewriters, reproduction machines, etc., does not intrude. This space should also house supplies and central files.

e. Equipment

(1) Each person should have his own desk. There should be a work or conference table for about every four team members.

(2) If classified material is to be involved there must be appropriate storage facilities.

(3) The team should have a reliable copy machine in its own area for its use only, or one reasonably available.

(4) Calculators should be provided as determined by need.  
(A rule-of-thumb indicates that one per man for auditors/price analysts will be necessary.)

(5) Adding machines should be provided as determined by need.  
(A rule-of-thumb indicates that one for every four men will be sufficient.)

(6) Offices occupied by the team chief, the deputy team chief, the operations officer, the subteam chiefs, and consultants (in

addition to the conference room) should be furnished with blackboards.

(7) Telephones should all be on unrestricted lines, preferably not requiring exit through the plant switchboard. At least one Autovon line and preferably two are desirable. One telephone is needed for each office except the subteam offices where one instrument for every four men is a minimum.

(8) The clerical staff will need desks and typewriters. Typewriters should have identical type to facilitate corrections.

f. Security

(1) All file cabinets and office space used by the team must be capable of being secured. Security measures must be adequate to preclude contractor's access to the team's work papers. This may mean changing the locks on the office doors, using files with locking bars and combination locks that can be set by the team.

(2) If the team requires access to classified data, provision for transmitting clearances for appropriate personnel must be made prior to the team's arrival.

(3) Badges or other identification permitting unrestricted and unescorted access to all of the facility for all members is required and should be pre-arranged for issue on the day of the member's arrival.

(4) Waste paper, if classified, must be so handled. All unclassified waste paper must be treated as "For Official Use Only" waste, and disposal provisions made accordingly.

g. Parking

Assignment of parking spaces by the contractor and possibly issuance of vehicle passes may be necessary.

h. Services

(1) Arrangements should be made to use the contractor's graphic arts facilities and reproduction services when required for non-sensitive graphics.

(2) The contractor may have other services such as check cashing, cafeteria, technical library, and the like available to the employees. Access to these services, as long as no gratuities or obligations are involved, should be made available for team personnel. When the contractor's check cashing facilities are used, extreme care must be taken to assure that there is no abuse of this privilege.

i. Supplies

(1) Don't stint. It is better for material to be unused than to hinder team productivity through a shortage of writing tables or pencils.

(2) Stocking a full line of office supplies may be necessary. If so, do so. However, the possibility of drawing supplies from the contractor's stationery stores and paying for them at the end of the study should be investigated. The cognizant DCAS office should also be contacted for assistance.

j. Clerical Support

(1) Under no circumstances should contractor personnel be used.

(2) In some cases, teams have used clerical staff from their home commands on TDY status. This has worked well, and is recommended whenever practicable.

(3) The possibility of borrowing help from the local government plant representative office, audit agency, or other government function located at the plant may be investigated. These agencies may also be able to engage temporary help for the team's use.

(4) At least one full-time clerk-typist will be required for the on-site effort. As the study continues, there will be a need for additional clerical help, some of which should be capable of using calculators and adding machines, and performing simple data-reduction tasks. The exact number of clerical personnel is to be determined by the team chief, and will ultimately be dictated by the size of the team, and the magnitude and complexity of the task.

(5) Before being accepted, all clerical help should be screened to insure they are not tied in any way through relationship or former employment to the contractor or his major suppliers.

(6) Telephones should be positioned so that one clerk can answer all incoming calls and take messages.

### 3. Requirements During the Report Preparation Phase

Normally the team will locate at the procuring commodity command to prepare the Should-Cost report. The administrative requirements are essentially the same as when on-site, except as noted below.

a. Office Accommodations

- (1) A library or central room will be needed for locating all the data brought back from the contractor's facility.
- (2) More typists will be required and more space will be needed for them.

b. Equipment

- (1) Calculators should be provided as needed. (A rule-of-thumb indicates that one for every team member will be necessary.)
- (2) The burden of complete re-typing of several drafts of the various parts of the report can be greatly eased through the use of automatic typewriters (such as IBM MTST or other similar equipment).

c. Clerical Support

- (1) Several drafts of the report, which may exceed 1,000 pages, will have to be typed. Competent, accurate typists and operators for the automatic typewriters will be needed. One typist for each four or five team members is normally required. The level of typing will reach this plateau about five to eight days after the team starts writing the report.
- (2) It will be necessary to have a head clerk to supervise the clerical staff and control the typing effort.

d. Supplies

If automatic typewriters are used, several dozen tape cartridges, paper rolls, or similar supplies will be required.

## CHAPTER 4

### PLANNING THE SHOULD-COST ANALYSIS

#### I. General

The importance of effective planning cannot be overstressed. The preparation and use of a good Should-Cost plan serves three important purposes:

1. It insures that the procuring agency and the team do in fact, consider the task at hand, how it is to be accomplished, what resources will be required, and what schedules must be met.
2. It provides an operating guide and checklist for the procuring agency, the team's managers, and the individual members to be used in performing their specific roles and insuring that significant tasks do not "fall through the cracks."
3. It serves as a control device against which progress may be measured and problems identified for corrective action.

#### II. Levels and Steps of Planning

1. There are essentially five levels of planning involved in a Should-Cost analysis. These levels generally determine who plans which activities, and in what time sequence. The elements covered in each level (illustrated in Figure 4-1 and described in the following paragraphs) are:

- a. The procuring agency's plan

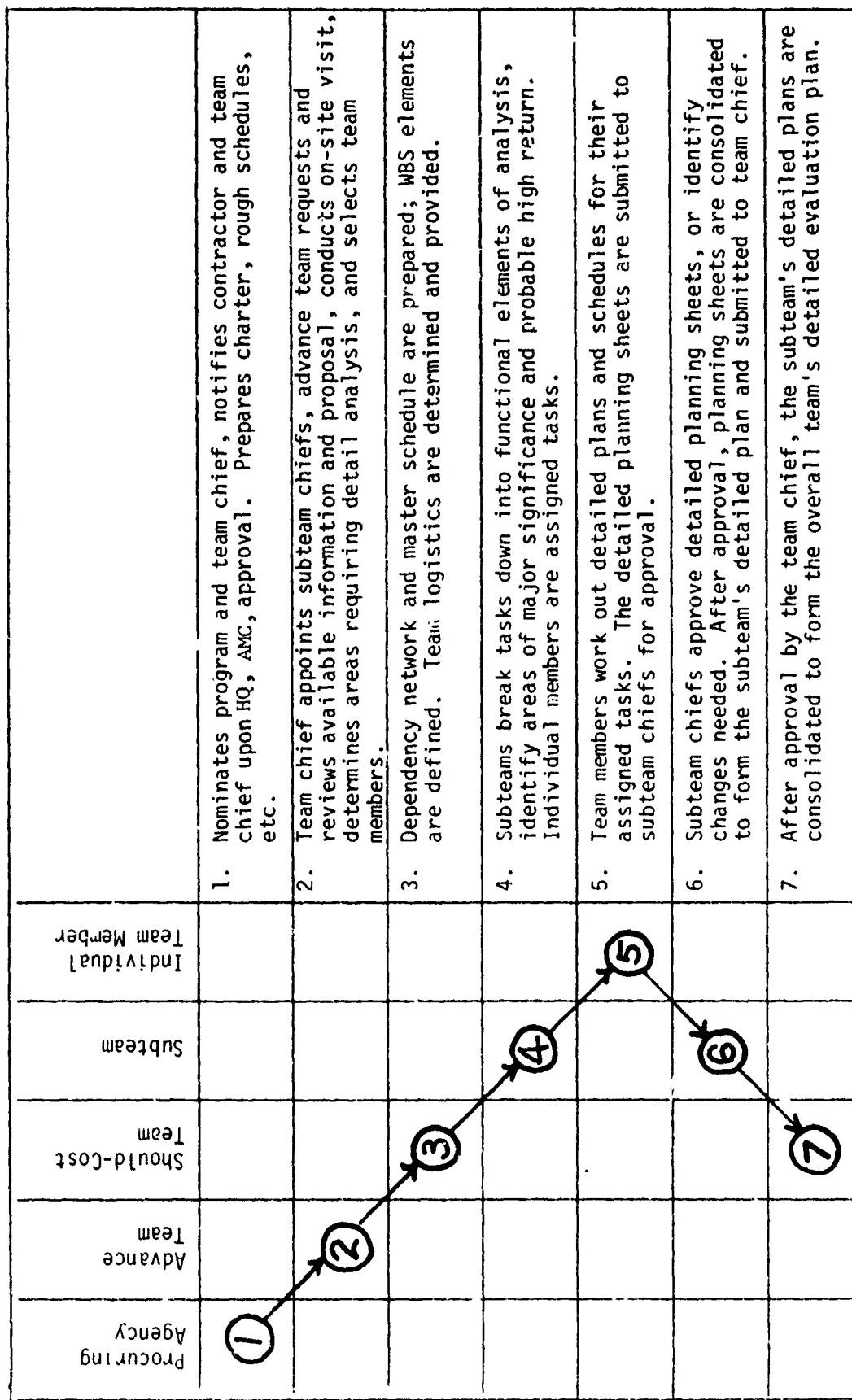


FIGURE 4-1  
ILLUSTRATION OF LEVELS AND INTERRELATIONSHIPS OF SHOULD-COST PLANNING

- b. The advance team's plan
  - c. The overall team's plan
  - d. The subteam's plans
  - e. The individual members' plans
2. The procuring agency's plan covers the following activities:
- a. Identification of the optimum program for analysis, nomination of a team chief, and submission to Headquarters, AMC (HQ, AMC) for approval (reference Chapter 2, paragraph 1, and AMCR 715-92, Should-Cost Analysis).
  - b. Issuance of a charter for the team chief, in accordance with AMCR 715-92, clearly establishing the task to be performed, his authority and responsibility during the analysis and negotiation, his lines of communication, reporting requirements, any necessary constraints established on time, resources, etc.
  - c. Notify the contractor of the planned analysis, after receiving HQ, AMC approval to undertake the analysis and the selection of the team chief (reference Chapter 2, paragraph 2, and AMCR 715-92).
3. The advance team plan will include:
- a. Selection of the subteam chiefs and other key members of the Should-Cost team. These individuals will comprise the advance team.

b. The proposal, previous proposals, information from other Government agencies, and information from the contractor should be reviewed.

c. The advance team's on-site visit should be planned and conducted in a manner to determine the specific areas needing detail analysis and the team members required to conduct this analysis.

4. The overall team's plan should be developed by the team's management in four steps:

a. A master schedule of the principal phases of the analysis as shown in Figure 4-2. The schedule should be prepared as early as possible in order to establish a framework for the detailed plans to be generated by the subteams and individual analysts.

b. A rough dependency network of the overall analysis showing the interrelationships and dependencies of the various elements. Such a network is too large and complex to present here in full, but a sample section covering direct labor is shown in Figure 4-3. An outline of the major elements of a dependency network is shown in Figure 4-4. (NOTE: Study plans and tasks are to be structured in such a manner that they can be tied to the contractor's proposal, and subsequently to the Should-Cost report.)

c. The administrative or logistical requirements of the team at the contractor's facilities must be determined and provided.

## SAMPLE MASTER SCHEDULE FOR A SHOULD-COST OPERATION (Weapon System, contractor's name)

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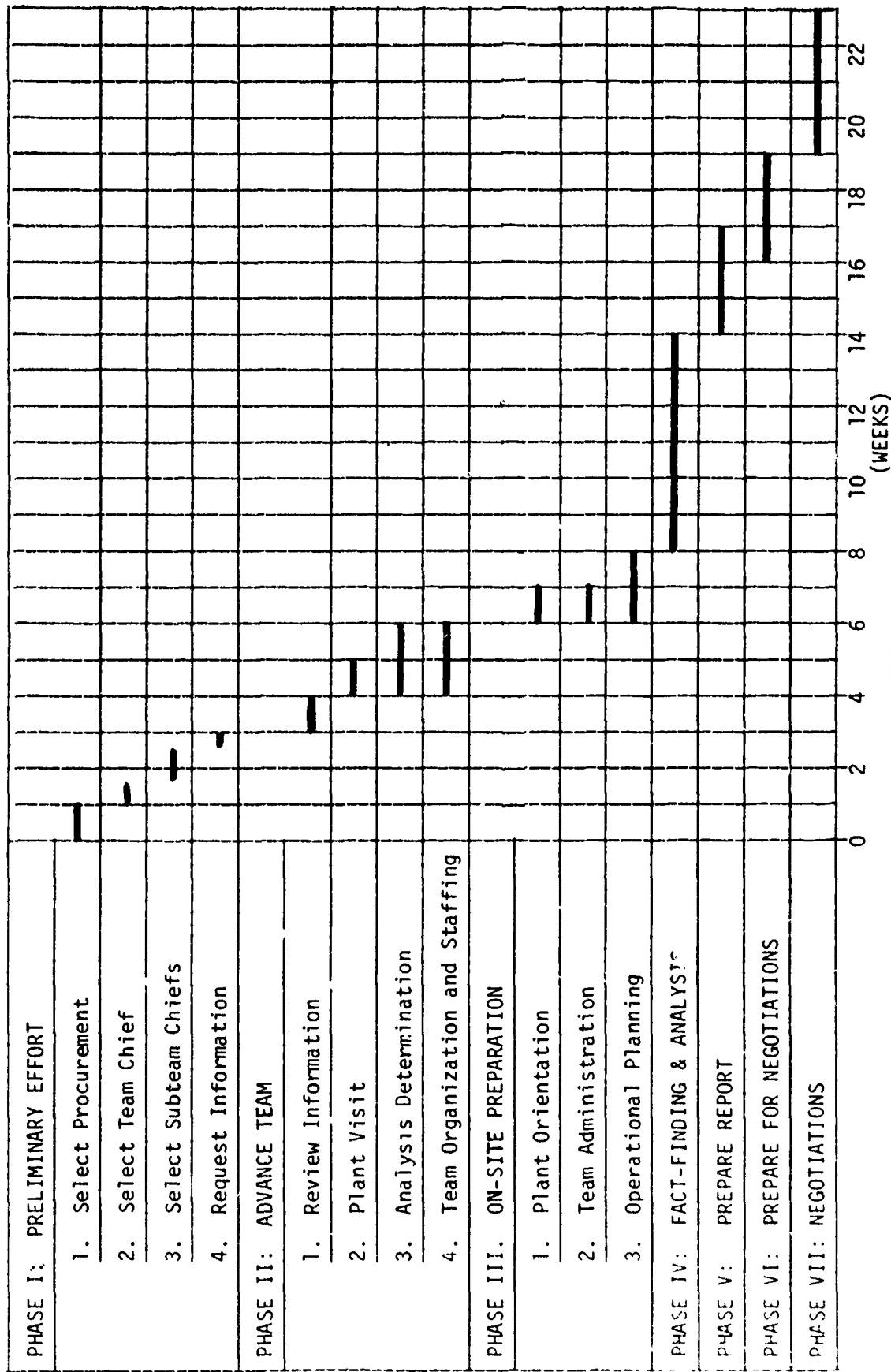


FIGURE 4-2  
EXAMPLE OF MASTER SCHEDULE FOR SHOULD-COST ANALYSIS

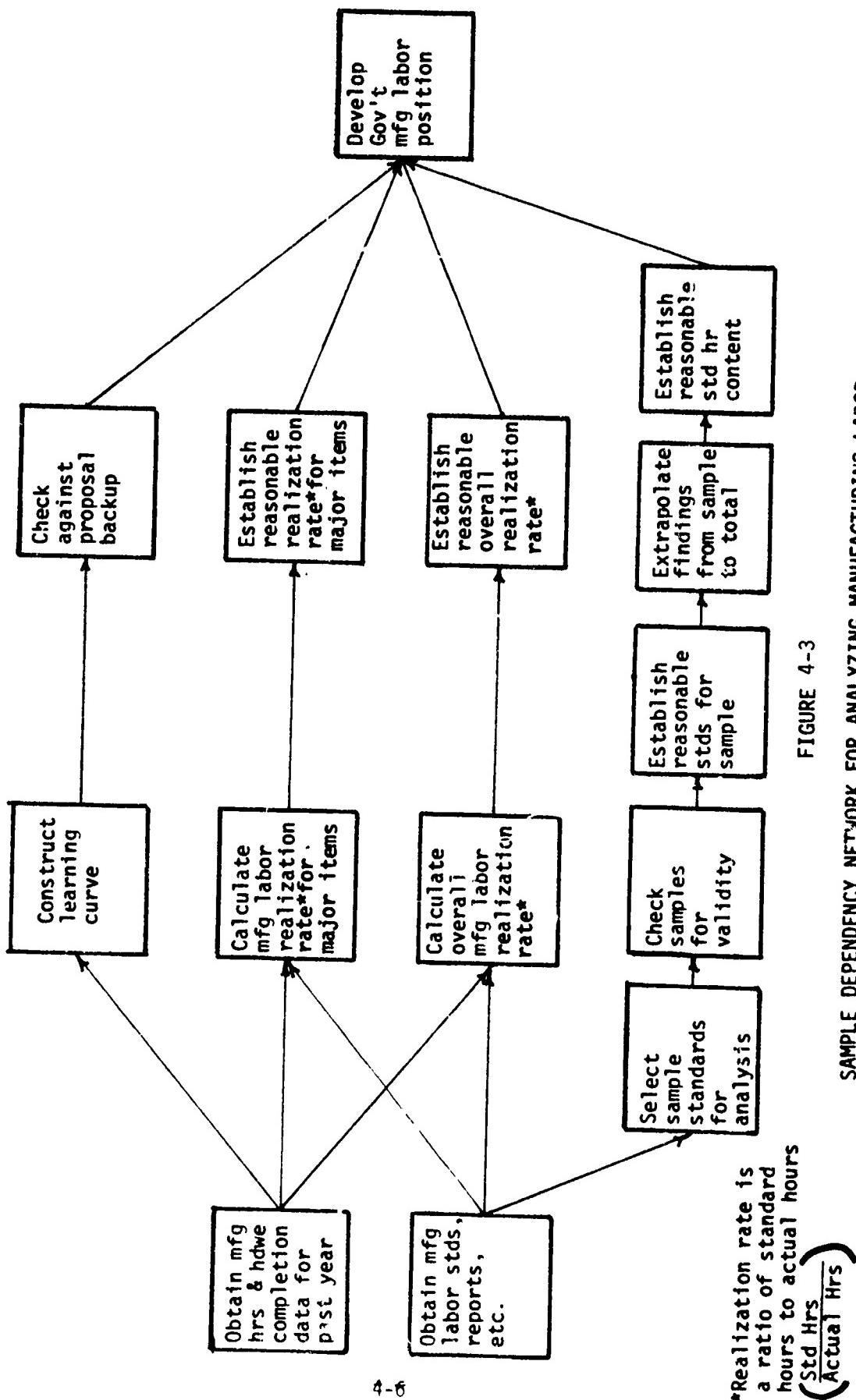


FIGURE 4-3

SAMPLE DEPENDENCY NETWORK FOR ANALYZING MANUFACTURING LABOR

SAMPLE OUTLINE OF MAJOR TASK ELEMENTS

TO BE COVERED IN DEPENDENCY NETWORK

A. Material Analyses

1. Interdivisional transfer and major subcontract
2. Purchased parts (high dollar value)
3. Purchased parts (low dollar value) and raw materials
4. Material Variance (applied factor)

B. Direct Labor Analyses

1. Labor which could be estimated through a standard labor content build-up
2. Direct Engineering and Technical labor
3. Apportioned or pooled labor
4. Direct estimated labor
5. Labor Variance (applied factor)

C. Wage Rate Analysis

D. Indirect Cost Analyses

1. Labor overhead pools
2. Engineering and technical labor overhead
3. General and administrative expenses
4. Bid and proposal (B&P) expense, as applicable
5. Independent research and development (IR&D) expense, as applicable
6. Any other indirect costs of significant amount

E. Management System Analysis

1. Organization
2. Purchasing system and make-or-buy
3. Management systems
4. Cost reduction programs

F. Fee/Profit, Incentive and Share Ratio Analysis

FIGURE 4-4

d. A consolidation of the detailed planning sheets prepared by the subteams. (Note: a complete set of detailed planning sheets from a previous analysis is included in the Should-Cost library.)

5. The subteam's planning by the subteam chiefs and key members requires a functional analysis of the contract tasks, a determination of the more significant elements and those most likely to need improvement, and assignments of specific subtasks to individual members.

(Note: Flow charts may be established to facilitate interchange of information among team members and to provide a means of team schedule control.) Beginning with this stage, it is suggested that the subteams consider the work breakdown structure (WBS) of the procurement and the possibility of structuring parts of the Should-Cost analysis around this breakdown. Figure 4-5 provides a graphic example of such a breakdown. It is important to note that this planning is used primarily to insure that all tasks are covered, and that each analyst is used to best advantage. In the illustration, for example, Task 1.1 and its subtasks might be assigned entirely to one specific group who would be responsible only for that task. Another possibility would be to assign subtasks to individuals or groups according to specialties. An industrial specialist, for example, might be involved in all subtasks of Task 1.1, direct manufacturing labor; and in subtasks 1.2.2, production engineering; and 1.3.2, process labor.

6. The individual members' plans are based on general guidance received from the team's master schedule (Figure 4-2) and dependency network, and the subteam's task breakdown and the responsibilities assigned to the individual. Usually, the individual team member will

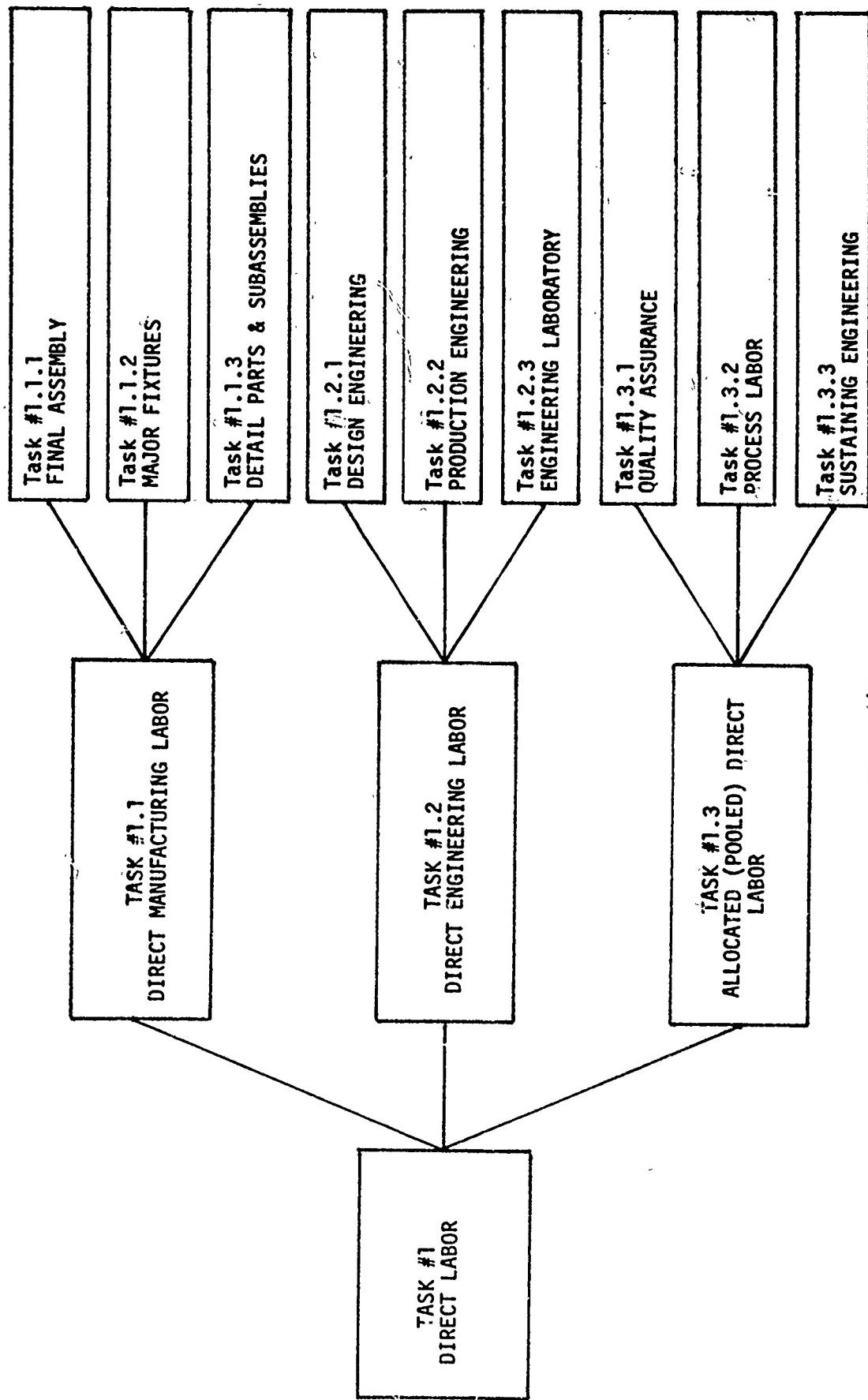


FIGURE 4-5  
EXAMPLE OF "WBS" APPROACH TO A SHOULD-COST TASK BREAKDOWN

begin by determining the analytical steps needed to complete his portion(s) of the effort, and the required data and support. This becomes the basic document of both the subteam's and the overall team's detailed evaluation plans. As already stated, the Should-Cost library contains a complete set of detailed planning sheets from a previous analysis. Figure 4-6 provides a sample of detailed planning sheets. These planning sheets are to be used only as a guide for preparing a new plan. After the individual member has thus established what is to be done, he must develop workable schedules for his effort. Figure 4-7 shows such a schedule. Note. These schedules are principally for the use of the individual team members and their subteam chiefs; they should be as informal as possible, and maintained in the analyst's possession for periodic review and tracking by the subteam chief.

### III. Summary

1. Effective planning is critical to the success of a Should-Cost analysis. All levels, from the individual analyst to the procuring agency, must be aware of the impact of their planning and actions on the plans and actions of the others.
2. It is essential that the planning operations be realistically and thoughtfully approached. Activities and schedules must be reasonable, and should consider the possibility of anomalies during the analysis. In brief, the plan must be a real plan, not just an assembly of paper for show.

3. Experience has shown a clear and definite relationship between the development of a sound operational plan and a smooth running and productive Should-Cost analysis.

MANUFACTURING LABOR	EVALUATION PLAN	1.1.1 FINAL ASSEMBLY	TEAM TECH/MFG
REQUIRED DATA AND SUPPORT			
	<p>1. Review drawings of the final assembly, subassemblies and individual parts in conjunction with process sheets, travelers, indentures, assembly traveliers, inspection and test procedures.</p> <p>2. After establishing method of assembly, tooling required and procedures, correlate with labor standards, crew loads and crew charts.</p> <p>3. Perform an on-site review of actual work in process, utilizing and annotating documents review to determine validity of documents used and efficiency of planned operation.</p> <p>4. Finalize review by:</p> <ul style="list-style-type: none"> <li>a. Considering possible and probable alternate methods of manufacture and assembly.</li> <li>b. Prepare a summary report with recommendations.</li> </ul>	<p>Parts Manual All drawings required. Process sheets related to drawings Travelers sheets related to drawings Indentures sheets related to drawings Assembly travelers sheets related to drawings Procedures sheets related to drawings Tool Listing Labor standards Crew loads Crew charts</p>	<p>Expected Results and Remarks Acquire a thorough knowledge of the Contractor's planned versus actual method of manufacture. Determine the standard hours required for final assembly. Determine the efficiency of his operation and make recommendations.</p>

FIGURE 4-6  
SAMPLE DETAILED PLANNING SHEET

TEAM MEMBER'S EVALUATION SCHEDULE	ANALYST/SUBTEAM	JONES / Eng & Tech
TASK # & TITLE	1.1.3 - DETAIL Parts & Subassemblies	
DATE ASSIGNMENT MADE	15 APR 70	DATE DUE 20 MAY 70
EVALUATION PLAN		SCHEDULE
1. REVIEW PARTS LISTS & DRAWINGS TO DETERMINE SIZE & SCOPE OF TASK	O → Δ	
2. DEVELOP SAMPLING PLAN TO SELECT ITEMS FOR DETAILED ANALYSIS.	○ → Δ	
3. REVIEW MFG METHODS FOR ITEMS IN SAMPLE.	○ → Δ	
4. DETERMINE IF LABOR STANDARDS ARE VALID. MAKE ANY ADJUSTMENTS NECESSARY.	○ → Δ	
5. USING VALIDATED STANDARDS, ESTIMATE MANHOURS FOR ITEMS IN SAMPLE.	○ → Δ	
6. USING ESTIMATE FOR SAMPLE, DEVELOP ESTIMATE BASED ON REVISION FOR ALL DETAIL PARTS & SUBASSEMBLIES.	○ → Δ	
KEY: START: O ACTION: _____ COMPLETION: Δ	15 17 19 21 23 25 27 29 1 3 5 7 9 11 13 15 17 19 21 23 25	APRIL MAY DATE:

FIGURE 4-7  
SAMPLE OF INDIVIDUAL TEAM MEMBER'S EVALUATION SCHEDULE

CHAPTER 5  
CONDUCTING THE SHOULD-COST ANALYSIS

I. General

1. This chapter discusses the team manager's roles in insuring the quality of the on-site Should-Cost team's effort. Specific elements and techniques of analysis are covered in Chapters 6 and 7.

2. During the analysis, the value of the detailed plan will become apparent as the team's operating guide and as a tool for controlling and tracking progress. It is to be expected that the plan will require revision to meet contingencies and unexpected developments.

3. Throughout all aspects of the analysis, two key considerations must be borne in mind. Although they are discussed in Chapter 6, it is appropriate that they be introduced at this time. They are:

a. The team's findings must be fully quantified (i.e., the cost impact of their recommendations must be logically and objectively supported and calculated). This is essential in order for the Government to develop and present its pricing position during negotiations.

b. In every possible instance, the basic data used to quantify and support the team's recommendations should be derived from reliable sources within the contractor's operation. This will

help strengthen the Government's pricing position because it is difficult for contractors to argue with their own source data.

**II. The Importance of Quality**

1. In conducting the analysis, as in selecting the team, quality must be the overriding consideration. Only if the contractor may be positively shown that the team's approach was logical and objective and that the data was realistically and accurately constructed in accordance with generally accepted and established principles, will he give credence to their findings and recommendations.

2. It is not sufficient to merely state that a certain dollar amount represents the difference between the contractor's proposal and the Should-Cost estimate. Rather, the analysis of each cost element should clearly state what factors account for the difference, whether the difference is occasioned by questions of fact or by opinions and judgments, and the probabilities of occurrence (normally stated in qualitative terms).

3. Hence, the analysis should indicate the "hardness" or "softness" of the Government's position and the degree to which it can be factually supported. In some areas of differences, the causes might be associated with duplication of costs, overstatements or computational errors. Here, the analyst's report would indicate that unless our facts are erroneous, no alternatives are appropriate.

4. But other differences, such as those based on an assessment of

the uncertainties of contract performance, contingencies which appear to be based on unrealistic estimates, and costs attributable to uneconomical or inefficient practices, require solid rationale to support the analyst's position. In these instances, the analyst should identify alternative positions that have a supportable basis.

5. Failure of team members to give adequate consideration to alternative positions, so that the negotiator may better develop a range of negotiating positions, has been a major shortcoming in some Should-Cost analyses.

### III. Team Orientation

1. The team chief must insure that all team members fully understand the team's task to include: understanding Should-Cost, the proposal under analysis, the objective, and their individual jobs. Members who have attended the Should-Cost Workshop or who have served on previous teams can contribute to the team's orientation.

2. The orientation should emphasize the following points:
  - a. The purpose and objective of the team's effort.
  - b. The importance of planning to the team.
  - c. The need for good communication and team member interfacing.
  - d. The absolute necessity for quantifying, justifying, and supporting the team's findings in order to support the Government's

negotiation objective.

e. Various techniques for quantifying, justifying and supporting findings as discussed in Chapters 6 and 7.

f. Review of AMCR 715-92: Should-Cost Analysis, this Guidebook, "Lessons Learned" and other Should-Cost research publications of the US Army Procurement Research Office.

g. The format of the team's Should-Cost Report.

h. The importance of using effective interviewing techniques for gathering data or information.

i. The expected conduct of the team members.

3. Following the above orientation, the team should receive plant tours and briefings by company personnel in accordance with schedules established in advance by the advance team and the contractor. The primary objective of the tours and briefings should be to develop a working knowledge of the overall operation, and what types of data and information are available. This is helpful in developing the data requests and insuring that detailed planning truly reflects the existing situation. These briefings and tours should be directed toward answering the following types of questions:

a. What is the nature of the company and its organization?

- b. Who are the key people in the organization?
- c. How is the product manufactured?
- d. What has been the evolution of the product's design?

What major changes have been incorporated?

- e. Where are things done? (Best handled as a plant tour.)
- f. How are things done in general?
- g. What is the situation with the labor force?

#### IV. Studying the Proposal

1. Some elements of the proposal and techniques for their analysis are discussed in the next two chapter(s). At this stage of the analysis, however, each team member should be given a copy of the proposal for his own use. Note: It is recognized that the size and complexity of some proposals may preclude giving a copy to each member. In such cases, the "rule of reason" will apply. In any case, however, each member should have at least a summary of the proposal and the detailed back up data applicable to his area of interest. The team should thoroughly review the entire package, concentrating on the following aspects:

- a. Structure of the proposal: Team members should know how the proposal was put together and which detailed schedules or formats support the summary schedules.

b. Rates and factors used within the proposal: Contractors will often include a section on overhead rates, general and administrative rates, and other rates for factored direct labor or other direct costs, material attrition rates, economic escalation factors, etc.

c. A comparison with previous proposals may be useful to determine if the structure has been modified, and if so, for what reason. Such a review may also help to identify cost areas which have historically been "soft," especially if cognizant audit and procurement people assist.

d. The areas of the proposal where the contractor's backup justification appears either strong or weak.

e. All areas of the proposal where the contractor may have made mathematical errors. If this situation occurs it will most often occur in carrying figures forward from one schedule to another or in converting manhour estimates to manmonth estimates and the like.

f. The areas of the proposal where it appears that the contractor has made a summary estimate for a cost item and then backed into a detailed justification by manipulating estimated production counts. Indications of this situation exist when summary manhours or manmonths exist in even increments of 10, 100 or equivalent men even though the purported justification appears not to exhibit any even, incremental pattern.

2. As the team reviews the proposal, it will identify many areas needing clarification or additional information. The contractor may then be asked to provide additional briefings to the overall team. Local Government audit and contract administration personnel should be invited to attend the briefings to clarify and comment upon the material presented by the contractor.

V. Data Gathering and Analysis

1. Following the contractor's briefings and proposal review, the detailed plans should be reviewed and revised as necessary. The team's managers and analysts will need to relate the data to the detailed plan, and possibly re-evaluate and revise their approach. Points that should be covered are:

- a. A translation list, converting the generic descriptions of data used in the plans to specific contractor terms and document titles.
- b. Identification of the voids in the information that the team had expected to receive.
- c. Decisions on work-arounds to fill the voids.
- d. Identification of "gray areas" where the existence or reliability of the data needed is not known.

2. With these elements agreed upon, the next steps in relating to the plans are to:

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a. Establish the first priority items of data needed for:

(1) long lead analytical work that must be started as soon as possible;

(2) clearing up the gray areas of data; and,

(3) analysis of the most significant elements of cost.

b. Establish lower order priorities for other data to be gathered.

c. Check the plans and lists of data to be acquired to make certain that the analysis will be able to develop a Should-Cost estimate for each of the contractor's proposed elements of cost.

3. Also relevant to data collection is the use of specialized briefings. Some topics will be covered in reasonable detail by the contractor in the initial round of briefings. As the team progresses with its work it is quite likely that some of these topics and specialized in-depth briefings will be of interest to almost all members. Sometimes, only one of the subteams will be involved. Additionally, the contractor may volunteer to present additional briefings in mid-study where the volume of team inquiry about certain subjects is large enough to make the briefing the most efficient method of transmitting the information. These would be incremental to the detailed briefings noted earlier.

4. The collection and analysis of data is usually begun at the general or summary levels, and worked bit-by-bit to the more specific and detailed supporting data. This approach will clearly require the analysts to interweave their data gathering and analytical work.

5. Data requests should be made through the team chief, with one individual (usually the operations officer) responsible for logging and controlling requests and responses for major or especially significant data items. All team members should be instructed on how the system works and how to tell if a certain item of data has been received to minimize the embarrassing possibility of requesting something that has already been transmitted. Because the contractor will quite likely set up a formal interface point for delivering data, the team's log of data received becomes its corresponding part of the interface. Written requests specifying exact data needs will aid the contractor to respond aptly.

6. The techniques applicable to information and data gathering revolve around two basic actions: first, determining what is wanted; and second, asking for it. At times this is much more difficult than it sounds.

a. Determining what data to ask for often involves problems of semantics. The titles of the contractor's reports or documents may not clearly describe their contents. Even when making requests in terms of the basic function or contents of the document, contractor personnel are sometimes unable to relate the requests to the

appropriate report or document. Therefore, very early in their data collection activities, the team must become familiar with the terminology used in the contractor's system and use it when making their requests. It is similarly important to understand how the contractor's systems work in order to be able to request the correct documents. The team member should strive to develop such a depth of understanding that he can recognize what types of information must exist in order for the particular system to function as it does.

b. As data is gathered it should be evaluated for accuracy. Sometimes this means close examination of all the inputs, processing, sorting, and other adjustments leading up to output. Other situations will call for some independent measurements or sampling to arrive at such calibration.

c. It is always good practice to trace down a particularly significant report or document to its source. Find out who is responsible for it and then discuss it in detail with him. The intent is to make certain that there are no hidden inferences or qualifications in the report or its preparation that would weaken or destroy any argument built upon its base of information. Another cross check can be made by referring to the procedures describing how the information is prepared and for what purpose.

d. Often, if one source for data fails, another may succeed--for instance, procurement lead times for major items should be known by both purchasing and master-scheduling personnel.

7. Information gathering through interviews will be of significant value to the team's study. Documents, tab runs and reports only tell part of the story. To really find out what is going on in a contractor's plant it is necessary to question people at the working level, supervisors, the foremen on the manufacturing line, the head of the budgets section, the chief estimator and so forth.

8. The team should plan to make their own independent studies to derive and verify information. The team leadership must make decisions early in the course of the study concerning the independent studies they wish to undertake. There are no hard and fast rules about where studies should or should not be made.

9. Assist audits, performed by Government audit offices, may be helpful in evaluating subcontract or interdivisional transfer cost data required by ASPR 3-807.3. The information gained may be especially helpful in analyzing the contractor's make-or-buy rationale, subcontract pricing, and competitive bidding practices. The role of contract audit as a pricing aid is covered in ASPR 3-809.

a. One problem that will exist with assist audits is the basic difference between a Should-Cost study and an accounting-based audit. It should also be borne in mind that the subcontract may not warrant a Should-Cost type of analysis.

b. Generally, an assist audit should be considered when the

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subcontract or interdivisional transfer price is to be negotiated on the basis of cost analysis and one or more of the following conditions exist:

- (1) the cost is significant,
- (2) the source has been used consistently,
- (3) there appears to be a lack of adequate price competition,
- (4) the source appears to have a competitive advantage over other possible sources.

c. Decisions to use assist audits must be made very early in the study to insure their completion in time for the team's use.

10. Each team member should keep a daily journal to record the information transmitted during interviews, dates, observations made, names of people contacted, and the like. The journals should be thought of as a vital written memory bank that records all the data and information gathered that was not in documented form. It will become a key reference during the later analysis and report writing, and may become a vital source of supporting substantiation for the negotiation. The journal should be kept up to date in permanent notebooks (such as spiral-type), and reviewed by the subteam chief every few days.

VI. Team Coordination

1. The coordination of effort in a Should-Cost analysis requires a free and cooperative interchange of problems, solutions, and findings among the members and leaders. Communications can best be handled either by discussions and/or written reports.

a. Discussions: The following approaches have been used:

(1) "Evening Staff" meetings, including the team chief, his deputy, and the subteam chiefs, conducted after working hours. The meetings were held daily, required about two hours, and gave fairly formal coverage to the status of each subteam's efforts, with emphasis on problem areas.

(2) "Breakfast Staff" meetings, including the team's managers and any individual members wanting to discuss a particular problem or achievement. These were held daily before working hours, required about an hour, and were quite informal.

(3) "Combinations," where the team's managers meet formally at regular intervals (such as weekly) and informally once or twice each day. This appears to be the preferred approach.

b. Written Reports. It has been found that some sort of written reports are essential to control the team's activities. Although the control method may vary with the circumstances, the following approach is suggested:

- (1) Each team member maintains his daily journal, as already described in paragraph 10, page 5-11.
- (2) Each member may be required to prepare a brief, informal, handwritten daily report, similar to the example in Figure 5-1, for his subteam chief. (Alternatively, a thorough review of each task with the assigned team member at predetermined intervals may be an equally effective method for determining team member progress.)
- (3) The subteam chiefs' review their analysts' reports, and prepare similarly brief and informal handwritten reports (see Figure 5-2) of their subteam's status for the operations officer and team chief. The analysts' reports should be used as supporting attachments to the subteam chiefs' reports.
- (4) All members should understand that the reports must be kept brief, so as to not unduly waste the team's time in preparing them. Above all, they should be factual and honest appraisals of the day-to-day operational situation, so that the team's managers can track and control the team's activities, and develop adjustments and corrective action when required.

Individual Team Member's Daily ReportAnalyst TRUEBLOODDate 6/23/71Subteam MANAGEMENT SYSTEMSShould-Cost "WBS" Task # 7.2Task Title MAKE-or-BUY (MoB)

1. Schedule Status EXPECT 4-5 DAYS SLIPPAGE
2. Today's activities: REVIEWED MoB PROPOSAL AND KR PROCEDURES & INSTRUCTIONS. DISCUSSED KR "MAKE" DECISIONS ON HYDRAULICS & GEARBOX WITH KR'S PROJECT MANAGER. FOLLOWED-UP ON REQUEST FOR MoB COST COMPARISONS, MINUTES OF MEETINGS, ETC.
3. Significant findings KR HAS GOOD PROCEDURES, IN ACCORD WITH ASPIR, BUT DOESN'T FOLLOW THEM.. NO COST COMPARISONS HAVE BEEN MADE. KR SAYS HYDRAULIC & GEARBOX "MADE" DECISIONS ARE DICATED BY OUR DELIVERY SKEDS.
4. Plans for tomorrow OBTAIN PAST MFG & PROC LEADTIMES; NEED INFO TO VERIFY/CHALLENGE KR POSITION ON OUR SKEDS & HIS MoB DECISIONS.
5. Remarks (Anticipated problems, needs for assistance, information that may be useful to other subteams, etc.): NEED HELP FROM PRODUCTION SUBTEAM ON NEED-DATES FOR HYDRAULICS & GEARBOXES -- MAYBE LATER ON COST COMPARISONS.

FIGURE 5-1

Subteam Chief's Daily Report

Subteam Chief

StrongheartDate 6/23/71Subteam Mgt Systems

1. Overall schedule status Generally on-target, but we may have a 4-5 day slip in Make-or-Buy
2. Activities covered, and subteam chief's comments:
  - a. "WBS" Task & Title 7.1 - Purchasing System  
Comment As Jones's report shows, he's a little ahead of sched -- maybe we can use him to help Trueblood on proc leadtimes.
  - b. "WBS" Task & Title 7.2 - Make-or-Buy  
Comment Looks like Kr has room for real improvement here; but verifying sched & leadtimes will be a real bear!
  - c. "WBS" Task & Title 7.3 - Wage & Salary  
Comment George's report looks good so far; no problems + on-sched.
  - d. "WBS" Task & Title 7.4 - Suggestion Program  
Comment Haven't started yet, George will handle when through with Wage & Salary, about 6/30
3. Remarks Our only real problem seems to be Make-or-Buy. I agree with Trueblood's appraisal: he needs help.

FIGURE 5-2

CHAPTER 6

ELEMENTS OF ANALYSIS

I. General

1. The elements of the Should-Cost analysis are directed at a quantitative evaluation of the contractor's proposal and his operations. His proposal will be studied and reviewed in the same manner as in "will cost," but to a greater detail. The analysis of his systems and operations for efficiencies and economic practices in Should-Cost is the other primary difference from "will cost." Because this feature of Should-Cost is relatively new to the Government, the emphasis of this chapter will be on the evaluation of contractor systems and operations.

2. The analysis should be approached in two phases. The first being problem area identification, and the second being cost documentation. The identification phase should determine those areas of costs that will require detail investigation. Much of this determination should be made prior to the Should-Cost team's arrival at the contractor's facilities or soon thereafter. The documentation phase will be the most involved and time consuming part of the analysis as its results have to provide the basis for the Government's negotiating position. In this respect, the findings should be clear, factual, and based on the contractor's own data where possible. This chapter is intended to assist the Should-Cost team in both phases of the analysis before and after entering the contractor's facilities.

## II. Off-Site and Advance Team Analysis

### 1. General

a. Prior to the arrival of the Should-Cost team at the contractor's facilities much of the initial analysis should have been completed. This first phase will involve a summary evaluation of available information and will result in the determination of those areas of the contractor's proposal and operations that will be analyzed in detail when the team arrives at the facilities. The off-site analysis is not quantitative, but rather a qualitative review of the information available in the proposal, during the advance team visit, from local Government agencies (DCAS, DCAA), and from other material requested from the contractor. Examples of the findings which might result from this analysis are as follows:

- (1) As detailed production scheduling is not a documented system, possible man and machine under-utilization should be analyzed.
- (2) As production standards are not systematically revised, standards used in the development of the proposal will have to be evaluated.
- (3) The company has been experiencing rather large inventory adjustments; therefore, the inventory control system should be analyzed.

b. If this initial analysis is conducted properly, very little wasted time should result when the Should-Cost team arrives on-site as the areas for detail analysis will already be specified.

### 2. Proposal

As a review of the information and cost elements in the proposal will give insight into the approach of the analysis, it is most imperative that all members of the advance team be very familiar with the

proposal. If the proposal is not available during the off-site analysis, previous proposals of the contractor should be reviewed. The review should be conducted in accordance with the direction found in Chapter 5, Section IV, and should result in the selection of those areas in the proposal which will require detail analysis. This selection should be primarily based on potential savings to the Government.

### 3. Local Government Agencies

Local DCAS, DCAA, and other Government agencies should be contacted concerning contractor information that they may have available. Frequently, these agencies have conducted studies on contractor's facilities and operation that may prove most valuable. However, a warning should be noted that many of these reports will be documenting what "is" and not what it "should be."

### 4. Requested Information

a. Most manufacturing firms will have or should have certain information, data, and procedure manuals readily available if they are properly managing their organizations. This material should be requested and reviewed before the advance team visits the facilities. By so doing, the advance team will be able to plan their visit to best utilize their time in their determination of the areas of the contractor's proposal and operations that should be investigated in detail. Because of the nature of the material, this request should not require much time or effort on the part of the contractor. If part of the request can not be met, the knowledge that the contractor does not have the information available will be a meaningful reply. For example,

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if the contractor is not able to supply information concerning scrap or spoilage reporting and control, possible savings in this area should be evaluated when the Should-Cost team arrives on-site.

b. The material to be requested will vary from contractor to contractor depending on the team's prior knowledge of the contractor's operations. The following is a list of possible material that should be requested and suggestions for its evaluation.

(1) Organization Chart

The organization of the firm should be reviewed for reasonable assignment of functions and possible undesirable duplications.

(2) Resume of Key Management

In-depth analysis of this material is not intended; however, the team's familiarity with this information may prove valuable.

(3) Financial Statements

(a) These statements for the previous five years should be requested and analyzed. If the contractor is a division of a larger corporation, request the division's financial information that was used by the parent company to prepare the corporate certified statement.

(b) The first part of the review of this information should be a trend analysis of the five years of data in which significant changes are looked for. The use of semi-log graph paper is recommended as the resulting graph will then represent the rate of

change in the financial variables. This trend analysis should be followed by an industry comparison of key business ratios. Here the contractor's ratios, as calculated from the financial statements, are compared to published industry ratios. Some of the ratios only evaluate financial position, and therefore, will not be of great value to the Should-Cost analysis. Other ratios like inventory to sales and capital assets to sales indicate if the contractor's inventory level is proper and if the assets are being properly utilized with respect to the company's level of sales. For this analysis, Dun and Bradstreet's Key Business Ratios will be a useful reference. It should be noted that these ratios are only indicators in that they point out possible areas for further analysis.

(4) Budgeting or Responsibility Accounting Procedures  
and Reports

Contractors will use different terms for the titling of their internal control system; however, regardless of its title, the procedures and reports requested here should be of the system by which each cost center's performance is measured on a periodic basis by comparing plan to actual. The procedures review will indicate if the budgeting system is properly developed from the lowest organizational levels upward; if each cost center's controllable costs are properly emphasized; if indirect costs are adequately planned and controlled; if the reports are organized in a manner consistent with required decision making; if both positive and negative variances require review and explanation; and if budgeting is or can be reconciled with financial statements. Quarterly or semi-annual summary budget

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reports for all cost centers should be reviewed to see that the plan to actual comparisons are reasonable. If they are not, the system possibly or probably is not accumulating actuals in an accurate manner. If available, these summary reports for the past five years should be analyzed with respect to cost growth by trend analysis as discussed in the financial statements section to determine where lack of control may be present. If a contractor is budgeting for inefficiencies, plan to actual comparisons will not point them out; therefore, cost trend analysis should be performed to provide sufficient evaluation of the budget results in respect to reasonable cost growth.

### (5) Chart of Accounts

This is a list of accounts to which recognized elements of costs are charged. It serves as the vehicle for collecting and segregating costs for the budgetary or control system. Thus, it should be reviewed to see that the accounts are adequate to support the system.

### (6) Cost Accounting Procedure Manual and Reports

The relationship between the budgeting system and cost accounting will vary from contractor to contractor, or they may even be considered one and the same. However, cost accounting is usually the more encompassing system in which budgeting is a subsystem. The cost accounting procedures should be reviewed to evaluate long-range planning, inventory valuation, income determination, cost allocations, product costing, depreciation methods, and various other functions that can be part of cost accounting. A list of reports that

cost accounting produces should be requested as these reports will provide much of the source data required by the Should-Cost team.

(7) Labor Control Procedures

The labor control system may be part of cost accounting; however, as most proposals are built up from direct labor hour estimates, emphasis should be stressed on reviewing all aspects of this system from standards development to short internal scheduling and control of labor. Sample standards should be requested to determine if they were satisfactorily developed and revised. It should be noted that all manufacturing methods changes will require standards revisions. It is most important that adequate floor reporting is accomplished to provide plan to actual comparisons on a timely basis. Reporting labor performance on jobs that were completed a month ago is of little value. Weekly reports are usually required to provide meaningful feedback in relation to labor control systems.

(8) Production Planning and Control Procedures

A review of this system should primarily determine the level of detail to which production is planned and controlled. Having an automated PERT or linear programming scheduling system of major components is not near as important as a detail manual Gantt chart system. It is often the inexpensive minor part that stops assembly lines, requires unnecessary setups, and causes excessive inventory build-up. Therefore, a lack of detail in this system will always indicate inefficiencies.

(9) Engineering Resource Planning and Control Procedures

Often Engineering is considered an indirect operation in which meaningful control is not required and cannot be implemented. Both of these assumptions are incorrect and lead to inefficiencies. Implementing a good control system is not easy, but the benefits are usually significant. Engineering supervisors should assign measurable units of work, estimate task durations, and monitor progress. Status reports should be quantified regularly.

(10) Data Processing Scheduling and Control Procedures

The data processing facilities will probably represent a considerable investment for the contractor and is possibly his most expensive single piece of equipment. Therefore, its proper utilization is essential. This can be ascertained partly by the degree to which the equipment is scheduled and controlled. Utilization reports which are required for effective control should measure man and machine performance.

(11) Reports Listing from Data Processing

This review will reveal additional sources of information.

(12) Inventory Control Procedures

The procedures should cover raw materials, purchased parts, in process inventory, staged inventory and finished goods. The system should be selective in that critical high value items require

perpetual control; average value not so critical items require periodic control; and minor parts can usually be properly controlled on a "two bin" basis. Inventory control is one area where procedures may look good but in practice the system may not work.

(13) Scrap or Waste Reporting and Control Procedures

Often scrap is reported for inventory accounting purposes only; however, this type of system does nothing to control scrap or waste. An adequate system should entail percentage or volume goals which are compared to actuals on a regular basis for each work center. This type of control may also be part of the budgeting system.

(14) Purchasing and Make-or-Buy Policy and Procedures

The review of this material should insure its consistency with ASPR requirements. This is another system in which policy and practice may not be the same.

(15) Union Contracts

They should be read for information purposes so that the team involvement will not violate contract agreements or cause labor problems for the contractor. Union contracts should be analyzed carefully to determine and verify wage increase and fringe benefit provisions, as well as other contractual arrangements.

c. As previously mentioned, the above list will not always be pertinent or available, and should not be considered all inclusive.

5. Advance Team Analysis

a. After adequate orientation of the contractor's operations

and facilities, the advance team should continue the preliminary analysis to determine those areas which will require detail analysis when the full Should-Cost team arrives. The involvement of the advance team is dependent on what has been accomplished prior to their arrival. If all the requested material was received and reviewed, the advance team should spend much of its time making sure that the policy, procedures and reports are actually being used properly in the contractor's operations, further evaluating these systems by interviewing the people who use them.

b. The systems that were not previously reviewed should be now. The evaluation should be both conceptual and operational. First, the concepts of the system need to be discussed with the system's manager. He should be able to describe the details of his system in thirty to forty-five minutes which will save considerable time when compared to reading and trying to comprehend manuals. After this familiarization of how the system should work, discuss its adequacy, usefulness and drawbacks with the people who have to work with it. The most rigorous test for a system is if it works or not.

c. As much of the advance team visit will be concerned with interviews, it is important to establish a schedule to be followed. Very early in the visit, the team should request the contractor to schedule all desired interviews for thirty to forty-five minutes. Following a schedule of this nature will not only minimize contractor interruptions, but will also provide a vehicle for controlling the team's visit. During these interviews it is recommended that

cross-functional area questions be asked. Ask production control questions about labor standards, inventory control, budgeting and data processing. Contractor personnel are going to be quite hesitant to discuss any inefficiencies or unsystematic practices. However, people are more likely to discuss problems in systems other than the one that they are responsible for or work with. Considerable tact should be used to get the most out of this type of interviewing. For example, do not ask production control if labor standards are accurate; ask if production control uses unadjusted labor standards in their scheduling. Do not ask manufacturing if inventory and production control functions are satisfactory; ask supervisors if they have to keep up with minor parts and if they have to make scheduling adjustments on the floor.

d. When the advance team leaves the contractor's facilities, enough information should have been reviewed and evaluated to determine the general tasks and requirements of the full Should-Cost effort.

### III. Detail Analysis

#### 1. General

a. The detail analysis, which begins with the arrival of the Should-Cost team at the contractor's facilities, should be approached in two phases. The first phase entails the documentation of systems which cause inefficiencies, and the second, the documentation of the increased costs which result from system failures. However, specific cost inefficiencies will not always relate to a specific system failure.

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For example, inadequate scheduling and poor inventory control may both cause under-utilization of men and machines. Therefore, the specific costs of under-utilization will not be directly assignable to each particular system problem. However, the approach of the analysis is "cause and effect" in that all causes of inefficiencies should be documented.

b. This section of Chapter 6 will describe attributes and deficiencies of many business systems, and where and how costs will be affected by the system's performance.

2. Organization

a. The outputs of this analysis are most difficult to translate into a quantified dollar impact upon the Government's price negotiation position. However, delving into the way in which the contractor is structured and organized to do business will often reveal many subtleties that might otherwise go unnoticed. These small influences are often cumulative and multiplied in their effects upon the cost of goods produced. If the organization is weak, the control exercised by it will also be weak.

b. Business structures are usually based on function, product line, or consistency with major buyers. Contractors may use any one or any combination of these organizational approaches to control business. Regardless of the approach, clear delineation should be made between line and staff functions and their authorities; and adequate profit center or cost center orientation must exist to measure management's performance.

c. When the structure is a combination of principles, careful evaluation should be given to possible duplication and lack of clear lines of responsibility and authority. Often a project control structure will be imposed on a basic functional or product line organization. This should only be done when the nature of particular products are complex and/or non-standard, or when the size of the contract or project merits extra control. This imposition of two structures on an organization is breeding ground for duplication and inadequate singular direction.

d. The degree of centralization is an important consideration in the evaluation. Duplication of functions such as production control, one for fabrication and one for assembly, may seem warranted by the large amount of work involved. However, by maintaining two organizations, where only one is required, the following inefficiencies result: the number of supervisors is needlessly increased; the opportunities for utilizing employees in multiple capacities are reduced; and the general cost for the function is higher than necessary. On the other hand, functions can become too centralized - one production control for two plants.

e. The determination of the number of levels in an organization provides little information for cost analysis, but when related to span of control and supervisor to worker ratio, this combination often affects individual performance in all levels of the organization. Depending upon the functions, span of control will be relatively large

where work is repetitive, planned in detail and isolated to a small area. Where work is diverse, complicated or imaginative, the span will be smaller. Personnel or Industrial Relations should be able to supply the data to determine the ratios of supervisors to workers.

In a production shop, ratios of one supervisor for 12 to 18 workers is common. In an engineering organization, which requires more creative effort, ratios of 1 to 10 would be expected. As a basic design proceeds toward product design and documentation stages, engineering supervisory ratios will more nearly resemble a production shop.

f. Organizations requiring multiple objectives at operational levels will often result in inefficiencies. If manufacturing controls production and inventories, the conflicting goals of maximizing production and minimizing inventory investment can rarely be balanced into an efficient operation. Frequently this situation will result in excessive inventories to support a maximum production level.

g. The cost of inefficiencies in organization will often be hidden in other areas of the cost analysis, such as labor performance, machine utilization, inventory turn, spoilage percentages and in many other areas. However, clear duplication should be analyzed in relation to the particular areas in which it is found.

### 3. Personnel

a. Employee satisfaction has a direct effect on many or all aspects of cost. The two most frequent measures of successful

personnel policies are absenteeism and personnel turnovers. Both of these are greatly affected by the specific location's unemployment levels. High absenteeism results in possible machine under-utilization and general costs associated with under-capacity production. Often management is forced to over-hire in an effort to prevent this under-utilization, and this will result in poor labor performance on those days in which too many workers are available.

b. High personnel turnovers lead to excessive hiring and training expenses. A trend or regression analysis of hiring and training expenses to total labor force should indicate periods of unsatisfactory cost increases. The needed data should be available from the Personnel or Industrial Relations Department.

c. Poor personnel policies will often manifest themselves in poor labor performance and machine under-utilization; however, when excessive costs can be directly measured as in personnel turnover, the cost analysis should be directed at the indirect categories which contain these costs.

#### 4. Clerical Control

a. If the nature of the contractor's business requires a large clerical staff, the performance of these individuals should be analyzed to ascertain possible inefficiencies. This analysis is intended for jobs that have repetitive elements. Secretarial positions will not be analyzed as the diversity of their tasks precludes measurement. The main idea regardless of the means is that clerical

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work must be controlled. This can be achieved with proper supervision, but in most cases supervision alone will not be adequate. Where applicable, clerical work should be batched into units of measurable work. These units should then be assigned to individuals for completion within a short time frame. Supervisors should then check to see that these short interval schedules are met by the workers. This technique of clerical control is called "short interval scheduling" or batch control. If this or some other technique is not used, large clerical operations will be inefficient.

b. Evaluation of excessive clerical costs can be measured by ratio delay analysis and by establishing batch standards for a sample of the work. Both of these approaches will be explained in detail in Chapter 7. The cost reduction potential should be documented as an excessive indirect allocation cost.

5. Budgeting and Indirect Costs

a. Indirect or overhead expenses are almost invariably the largest single element of cost within a contractor's proposal, and therefore warrant thorough evaluation. Generally, contractors will employ one or more labor overhead rates, a material overhead rate, and a general and administrative (G&A) expense rate, all of which are used to allocate indirect expenses to contracts. It is not uncommon for contractors to experience labor overhead rates in excess of 100% of direct labor costs, and sometimes much higher. Unfortunately, the rates cannot be compared directly from one plant to another. What

one contractor classifies as a direct cost, another may consider as indirect. Thus, depending on the composition of their overhead pools, a contractor with a labor overhead rate of 100% may not be operating his plant with as much attention to efficiency and good control of indirect costs as his neighbor who has a nominal overhead of 150%. As with wage rates, overhead rates nearly always are included within a forward pricing agreement. The supporting data for the rates should provide the take-off point for the Should-Cost study of indirect costs. The local audit agency also will have records of the indirect costs for previous periods.

b. One of the contractor's major controls of indirect costs will be his budgeting system. The analyst should become very familiar with this system as it not only controls indirect costs, but also provides the contractor the basic information required to prepare the indirect costs and their allocations in the proposal. A weak budgeting system usually indicates excessive indirect costs.

c. The review of the budgetary system should document all aspects of the procedures from the development of the budgets to the actions taken when deviations occur. Concentrate on cost control at the management level having cost center responsibilities. Determine what part the budgets play in management reporting and who reviews actual versus planned. The budget reports should be timely, exception oriented, and follow the organization structure. Review the method of allocation and distribution of indirect pool costs to see if there

is consistency with the methods and rates used in the proposal. If the system is responsibility oriented, emphasis should exist on controllable expenses. Consider the adequacy of data flow, collection and preparation. With the completion of the budgeting system's evaluation, the analysis of the indirect costs as found in the proposal should be easier and more thorough.

d. The analysis of overhead rates is separated into three parts: evaluation to determine whether indirect costs are properly classified; evaluation to determine whether the method of allocation is equitable; and evaluation to determine the necessary level of indirect costs in the context of efficient management and control.

e. Although certain overhead costs may be reasonable and proper as indirect costs under the circumstances existing at a particular point in time, conditions can and do change. The analyst should review the conditions which led to the categorization of the various types of indirect costs. If conditions have changed to the point that some elements of indirect cost are no longer properly part of overhead, they should be deleted from the pools. The converse also may be true. It should be noted, however, that such changes affect other than just the instant contract. Therefore, the Should-Cost position must take into account the total effect of the change.

f. Just as the analyst must be alert to the classification of overhead expenses, he must also evaluate the relationship of the pool and its base of allocation. In many ways this is similar to

the analysis of factored or allocated direct effort. There must be a relationship of equity or benefit between the pool and the base.

The following examples illustrate the importance of the relationship.

(1) Assume that a contractor originally opened a facility and set up operations as a production plant. All direct effort was applied toward manufacturing. The contractor properly established a single manufacturing overhead pool, distributed across the direct manufacturing labor base. Initially, engineering was confined to planning product improvements and preparing documentation for customer-directed changes. As time passed, the contractor added more engineering effort. Later, development contracts were performed in addition to the manufacturing effort. In such a case, the use of a single overhead pool distributed over all direct labor (manufacturing and engineering) is no longer equitable. The type, amount, and cost of most indirect support is not the same for manufacturing labor as it is for engineering labor.

(2) Another example of inequitable indirect cost allocation can occur if a contractor has initiated a new product line which does not yet enjoy a high sales volume or large direct labor base. Frequently, costs normally classified as direct, or even indirect, may be charged to G&A. Some of the cost of the new project may thus be shared inequitably by the existing business.

g. Inequities in allocations should be guarded against. The Government ought to pay for its fair share of contract costs, but not for costs that equitably should be borne by other contracts or

commercial customers.

h. Each element of cost that contributes to the various indirect pools must be analyzed and evaluated separately. Generally a contractor will have a chart of accounts that will detail the development of the pools.

i. Indirect labor, almost without exception, is the largest contributor of cost to the overhead pools and hence warrants considerable attention and effort. There is no single analytical technique or approach that will provide a complete Should-Cost position, but the following considerations should prove helpful.

(1) Indirect labor is often characterized as being primarily service-oriented. It is not associated with physical output in the same sense as direct labor. This does not mean, however, that the efforts of indirect personnel cannot be planned, measured and efficiently controlled. The contractor may well employ some type of indirect work measurement program, or clerical/service labor work measurement program, that covers indirect personnel. In such a case, the program should be investigated. Questions such as the following are appropriate: how is the work of indirect personnel planned, measured, controlled; how does the measurement program tie to the overall indirect budgeting process; and what levels of realization have been experienced and what significant results in indirect manpower reductions has the contractor achieved as a result of the measurement program?

(2) Another aspect that should be investigated is the classification of direct and indirect employees. Certain job classifications will normally be applied only to direct people, and should be different from job classifications assigned to indirect people. Another method employed by some contractors is to set up "charge numbers" (or accounts) for indirect work, used by all employees. Effective control is more difficult in this situation because the distinction between direct and indirect becomes blurred. The more this condition exists, the more it is that indirect budgets or targets are unenforceable. The team can determine whether the situation exists by analyzing the ratio of direct classified personnel charging to indirect accounts (direct on indirect, or "D on I"). Sometimes, this cannot be done because no classification system exists. If, however, one does exist, the trends of "D on I" may prove useful in explaining changes in overhead rates.

j. If the contractor is not conducting a continuing program of work measurement in his indirect functions, it is appropriate for the team to consider conducting its own work measurement program. This may vary from quantifying manhours per purchase order to square footage serviced per custodian. When measurable output is not of sufficient size or quantity to be statistically valid, the use of a ratio delay study may be indicated.

k. Trend analysis of indirect costs to direct manhour ratios will often point out periods of unsatisfactory control. The evaluation

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should include the effect of periods of loss or increase in business on these ratios. These ratios are applicable to all indirect costs - not just labor; however, the base in some cases may not be direct manhours.

1. Ratio delay techniques are often useful to determine the efficiency of indirect labor. The analyst should remember that the overall intent of these analyses is to determine the extent to which the contractor is obtaining reasonably efficient use of his indirect labor force. The difference between what the contractor is realizing from his indirect people, and what he should be realizing, is quantifiable in terms of a reduction in indirect staff and overhead rates.

m. A useful approach in examining other indirect costs is to determine and review their historical relationships to other items. One such technique for performing regression analyses of various indirect expenses against a multiplicity of bases is the Probability of Incurring Estimated Cost, or PIE Cost technique. This technique is currently being tested and appears to hold great promise for future applications. A detailed discussion of PIE Cost is beyond the scope of this guide. However, the team should acquaint itself with the technique and make a determination of whether it might be used effectively as part of their Should-Cost study.

n. Even if the PIE Cost should not prove practical because of time or manpower constraints, the team should attempt to check the contractor's projections of indirect expense items against historical

actuals in addition to analyzing them for reasonableness. For example, one would expect that manufacturing expendable expenses -- cutting oil, etc., would vary directly with the amount of direct fabrication labor. If historical evidence supports this finding but the forecasted situation in which the proposal will be worked is significantly different, then the reasons for the proposed amounts must be found. In a similar analyses, if certain elements of other indirect cost which would be expected to vary directly with other factors are found to be increasing rather than showing a consistent relationship over a period of time (and the increase is not explainable by inflationary factors), then this may indicate a take-off point for analysis. Analytical results of this type can point to places where lack of attention by the contractor management has allowed creeping inefficiencies to continually push indirect costs upward.

o. The analyst, however, should never lose sight of the fact that even the most sophisticated projection techniques are meaningless unless the quality of the base has first been established. In other words, careful analysis of the historical data must always be performed prior to the application of projection techniques. The quality of the projection is only as good as the data on which it is based. In addition to accuracy and pertinency, the term "quality" is meant to encompass reasonableness, efficiency, economy, or, in short, the Should-Cost approach.

6. Purchasing

a. Most companies establish rather comprehensive policies,

practices and standard operating instructions for their purchasing organizations. As a first step these documents should be examined in detail. They will tell the analyst how the function is supposed to operate. The next step is to observe actual practices -- how buyers, expeditors, supervisors and analysts all go about their daily work. Deviations from prescribed practices will become obvious after a short sampling of the operation. Deviations are not necessarily undesirable. The procedures may be inadequate or outdated, and the purchasing personnel may be actually following more efficient practices in those instances where they depart from the rule book.

b. Normally, the analyst would expect to find any purchasing operation that is efficient endeavoring to procure the required materials and services at a minimum cost observing the following practices. Quantities are purchased sufficiently large enough to obtain the most advantageous price yet not so large as to create problems with surplus amounts of inventories. Purchases are finalized only after securing truly competitive bids, including competition in the cases of interdivisional buys. Management exercises prudent control over major subcontracts including the use of dual-sourcing and Should-Cost analyses when appropriate. Close liaison is maintained with the engineering, production control and production scheduling functions to minimize parts shortage problems--particularly those caused by product changes and production start-up problems. Source selection files are adequate and updated in relation to vendor performance and prices. Policy is clear and followed as to when Make-or-Buy analysis should be conducted.

c. In the evaluation of how the purchasing department functions ~ the analyst should investigate the in-and-out information flow. This should include not only routine purchase requisitions, but also the pre-release, advance copies of the production bills of material, the production release schedule requirements and the like.

## 7. Material Requirements

### a. Raw Materials

(1) Analysis of the contractor's raw material estimate relies heavily upon the team member's experience. One approach that can be used is to develop some measure of the amount of raw materials required by weight, square footage or cubic volume of finished product. A careful review of the processes through which the material is put during manufacture will indicate how much material is cut or etched or burned away in order to produce the finished item. From this, an estimate can be made of the amount of material unavoidably wasted in the manufacturing process. When this amount is added to the amount of material in the finished item, it should approximate the contractor's estimate.

(2) This counter-estimate will serve only as an approximation, not an exact figure. Therefore, only if there is a gross difference between the Should-Cost figure and the contractor's proposed amounts should the item be pursued in depth. Rarely is the value of raw material large enough to substantially affect the Should-Cost price position. An exception to this, however, would be when there is a large use of precious metals or exotic composite materials.

b. Bin Stock

(1) Minimal value piece parts are sometimes called "bin stock" or "free parts." They are items with a unit cost below some maximum figure, usually \$1. Their incorporation into the end product is not recorded on a material order or requisition. Instead, the parts are stocked at the work station to be used as needed in the assembly of the subassemblies and units. The kinds of parts that are usually categorized and handled in this manner include rivets, nuts, washers, bolts, small resistors and capacitors, small light bulbs, connector pins, clevis pins and cotter pins.

(2) The costs of these parts are usually pooled and the total cost of the pool allocated back to the various contracts in some manner. The allocation may be based on the gross weight of the item (heavier items assumed to use more line stock items), on the basis of a sample use for part of a unit from which a total use is estimated, or on some figure of complexity or even a detailed total use requirement developed from the drawings and bill of material. Based on the knowledge of how many units were passing through the shop for a period of time, of what contracts the units are identified with, and the total line stock usage for the period, it is then a relatively simple problem to allocate the cost.

(3) To complete the Should-Cost evaluation of this cost element, the analysts can approach the task by obtaining answers to the following questions. What kinds of parts does the contractor include in his line stock or bin stock parts category? What are the

price limits or other criteria that determine what is or is not in the bin stock? (Accounting policies may be a good source of this.) How are the bin stocked items controlled? How is usage measured? How are the costs pooled and allocated? How does the pooling and allocation relate to the estimating system? Is it equitable? How does the contractor estimate the proposal costs for bin stocked parts? What correlation can be derived from comparing recent historical cost and use of bin stocked parts to weight of finished products, structural density ratios, assembly manhours per unit, etc.? Does observation of how bin stock parts are handled on the factory floor indicate a general conformance to the governing procedures? Does it indicate areas where greater efficiency and less loss is possible? Are there items in the selection of uncontrolled small parts that should be controlled because of their attractiveness for pilferage? As with raw materials, the minimal value parts rarely offer targets for contributing substantially to the negotiating price position. Only when there are gross discrepancies will significant savings be developed.

c. Purchased Parts

(1) The initial approach to the evaluation of the contractor's proposed costs for purchased parts is to establish the required quantities. This involves building up a per-unit bill of materials to the contract quantity of units plus allowances for attrition. The analyst should sample several subassemblies and cross

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check the quantities shown on production drawings with the bill of materials.

(2) The next step is to examine the prices for the purchased parts that the contractor has proposed. Here, observations of the various practices of the purchasing function will come into play. Are the prices based on a catalog or price list, or has some attempt been made to obtain more favorable prices? Are parts bought contract by contract, or is a continuing attempt made to get price breaks by large-scale purchase of parts used on several products or contracts?

(3) It is often useful to select a small sample of parts from the bill of materials and have the contractor send out requests for quotes. The suppliers' quotes can then be compared to the prices the contractor is proposing. Team members can usually draw from their experience in suggesting specific suppliers to whom to go for quotes in addition to those favored by the contractor. If the contractor's proposed parts prices within the sample are similar to the quotes obtained, the proposed price for parts outside the sample probably can be assumed to be current also. If, however, there are significant and constant variances, two courses of additional action are warranted. The first is to enlarge the sample and request additional quotes to confirm the initial findings. The second is to apply appropriate statistical techniques to derive an adjustment factor to apply to the whole of the parts prices in order to bring them in line with the team's findings. Some contractors base proposed prices on

information in their standard cost files. In these cases, the files must be examined. The intent is to determine if the standard costs being used are valid, and if the costs reflect the current situation. Where an adjustment factor has been applied to the standard costs to reflect inflationary cost increases, this factor must be checked for validity also. This investigation also should include a review of the techniques employed to establish and update the standard costs. The definition of what constitutes a subcontract will vary from one contractor to another. In some cases any purchase order over some dollar limit, for example \$25,000, is known as a subcontract. Another criteria, sometimes applied, is whether or not the item is a stock or catalog item or whether some modification is required. If it is off-the-shelf, it is bought on a purchase order. If it is a special or modified item, it is bought via a subcontract. Clearly then, the analyst must first determine just what the contractor defines as a subcontract.

d. Subcontracted Items

(1) Next, the analyst should select a sample of the items to be subcontracted. If there are not too many items, and their dollar worth is a significant part of the proposal, investigatory steps should include the following. Investigate any previous subcontracts or procurements of the item. From whom were they bought? Who were the competing suppliers? What unit cost trends are evident? Look at the usage of the item. Is it used only on the proposed effort

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or is it common to other contracts or products? How is it bought--by contract or by anticipated total use? Can an existing contract be amended for the additional quantity rather than writing another contract? Look at the basis for the proposed cost. Were new quotes obtained? From whom? How valid was the competition--did all qualified vendors have a chance to bid? Look at the costs of other sources of supply. Has the contractor ever manufactured the subcontracted item? How did his cost compare with the purchase cost? How do the costs of other vendors compare to the one selected this time? Look at the records of the contractor's source selection studies. What do they indicate about the probable costs when buying from alternate sources of supply? Has the contractor conducted any Should-Cost studies on his suppliers? If so, what were the results? The analyst probably will find any problem with subcontracts intermingled with the make-or-buy decision process. The items that are considered as eligible for outside purchase rather than inside make usually are purchased through the subcontract mechanism. Thus, another source of information is the records used to support make-or-buy decisions.

e. Price Variance

(1) The analyst can expect to find some differences between prices proposed and vendor catalog and quotes for purchased parts, raw material, bin stock items and subcontracted components. Variances might exist between the proposed bill of material prices and what is currently being paid for the item; the standard cost of the item; and the costs

indicated by forward projection of historical price trends.

These variances may be significant even after various inflator/deflator factors have been applied.

(2) The recommended approach is to establish some baseline price, such as the last buy of the item, and then quantify the variance between the proposal and the baseline. By using a fair sized sample of parts or components from the proposal bill of material, the reasons for each difference can be sought out. If the same kinds of answers continually show up then this, of course, points to the next step--to find out if these are answers or excuses.

(3) Across-the-board adjustment factors for price increases due to inflation or other causes should be examined in detail. The Department of Commerce's Bureau of Labor Statistics is a good source for data. Examination of these adjustment factors may be more profitable than an item-by-item testing of unit prices and extensions.

#### f. Usage Variance

(1) It is a common experience in assembly operations that some percentage of the components and parts will be damaged, lost or otherwise unavailable for use. Over a period of time this experience can be quantified. The quantification produces a generally consistent factor or percentage by type of part representing loss or spoilage. This factor is referred to by such titles as "attrition factor," "line loss," "spoiled parts," "scrapped parts," etc.

(2) Therefore, to provide for the quantity of parts to be actually used in an assembly operation, the contractor must buy more than the bill of material indicated for the contract. This increment is determined by applying an attrition factor to the production requirement. This may be 12% or 1% or 5%, usually varying with the kind of part. In electronic assembly, a higher line loss would be expected for active components such as diodes, transistors than for passive components such as capacitors or resistors since the former are often more susceptible to damage due to handling and assembly.

(3) The analyst's exposure to the experience of other contractors should provide a valid judgmental base. How does the contractor being examined compare with other companies in the same business? This is a good way to roughly determine if the proposed attrition variances are out of line.

(4) The key to the Should-Cost analysis of these attrition factors is to examine how they were developed, how they are updated and what is being done to minimize them. The analyst will also want to talk with the people charged with the task of minimizing scrap and attrition.

(5) This kind of expense should be controlled. The team's approach should be to see if the contractor is pursuing a reasonable and effective course of action to control the attrition variance. Usually as part of the budgetary system, volume or percentage waste or

scrap goals for each cost center should be established with periodic reporting of actuals against plan. The analyst should be alert to such practices as the application of the attrition factor against bills of material that may already include "over and above" quantities.

#### 8. Make-or-Buy Practices

a. The Government buys management from the prime contractor, along with goods and services, and places responsibility on him to manage programs to the best of his ability, including placing and administering subcontracts as necessary to assure performance at the lowest overall cost to the Government. The purpose of analyzing the contractor's Make-or-Buy system is to determine whether his policies, procedures, and proposal give adequate consideration to the Government policies and interests as a "customer."

b. Analysts should review and thoroughly understand DOD policies concerning Make-or-Buy, as stated in ASPR 3-900, before starting their evaluation of the Make-or-Buy system and proposal. Several valuable references on the subject are contained in the Should-Cost Reference Library. Analysts should also review the Make-or-Buy Annexes of previous Should-Cost reports, as they may suggest techniques and alternatives under similar conditions.

c. A Make-or-Buy analysis will usually be conducted approximately as follows. Identify, examine, and evaluate the contractor's system of Make-or-Buy policies, procedures and practices. Evaluate

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for conformance with Government policy and sound business practice. Review current and past proposals, correspondence, back-up data, and minutes of meetings to determine whether the contractor is complying with his procedures. Discuss the system with the contractor to clarify any questions. Identify the items meeting the ASPR 3-902 cost criteria for consideration in the Make-or-Buy plan (i.e., items costing 1% of the contract value or \$500,000., whichever is less). Note: If the number of such items is large, the remaining steps may be applied on a representative statistical sampling basic including the highest value items. Determine which of the items actually permit a choice between making or buying, within the operational realities of production and procurement capabilities, leadtimes, and delivery schedules. Develop make and buy cost comparisons for items identified as actually permitting a choice between make or buy. Determine whether the contractor's decisions protect the Government's interests, and if not, determine the cost impact and apply it in the Should-Cost position. Whenever sampling is used, the analyst must be certain of its statistical validity. It is recommended that he request assistance from another team member or consultant qualified in statistical techniques.

**9. Inventory Control**

a. The primary objective of the inventory control system is to maintain the minimum amount of inventory consistent with manufacturing requirements. As part of this function, the physical location of inventories is important if they are going to meet manufacturing demands. Having the inventory on records, but not knowing its location, does not meet the objective of inventory control.

b. Inventory locations will usually be classified as raw materials, inprocess, staged or finished goods. This alone does not document the physical location. Thus, as part of the basic inventory records, locations should be specified as to warehouses, bins, and shelves. In relation to this, inventory adjustments from physical counts should not only quantify dollar delineation, but should also identify inventories that are improperly located.

c. The contractor should utilize some type of selective control system over inventories. This will entail the classification of inventory in at least three categories--priority items, intermediate items, and minor parts. The priority items will be so designated because of their value or importance to schedules. These goods will be controlled on a perpetual basis. That is, they will be continuously reviewed in that every item used will be posted and the new balance on hand plus the amount on backorder will be compared to an established reorder point.

d. Intermediate items are not significantly valuable and do not have scheduling importance; therefore, they are usually controlled on a periodic basis. Here, on an established monthly or weekly schedule, inventory levels are reviewed. This can be accomplished by physicals or by a one time adjustment to the records of the period's inventory usages to determine the present balance on hand. If this balance on hand plus on order is below the reorder point, the system should generate a purchase order or a production order depending on the nature of the item.

phase of this process involves converting manufacturing requirements through engineered or historical standards into man and/or machine hour requirements. These requirements are then loaded against the known man and/or machine hour capacities of each work center. The resulting production orders from this loading process should contain start times, completion times and man/machine hour requirements.

c. It is important that enough work is scheduled so that the men available in each work center will have adequate work to "make standard." For example, one week a particular work center's performance is only sixty percent of capacity and the following week production control only loads that work center by sixty percent expecting that this will be the amount of work completed during the week based on the center's recent performance. In this case, it should be clear that production control is perpetuating inefficiencies by scheduling them. Having loaded the work center at sixty percent, the work center will probably meet schedule and be forty percent inefficient. Is it the production workers' fault?

d. This leads into another important aspect of scheduling that every production supervisor knows and uses. Schedules can be beaten by over-manning, and efficiencies can be increased by under-manning. Therefore, production control reports should contain production order plan and actual start and stop times, as well as man and machine efficiency information.

e. Production control should also let manufacturing know where potential bottlenecks exist so that special attention can be given to these areas. They should also be involved with plant engineering in the scheduling of preventive maintenance. Machine downtime is considerably less interruptive and costly when it is planned. Economic order quantities, as specified by inventory control or as determined by production control, should be scheduled.

f. If the production control function is not adequate, the resulting inefficiencies will occur as under-utilization of men and machines.

## 11. Labor Control

a. In nearly all cases, the direct labor estimate is the foundation of the contractor's proposal. Analysis of labor costs represent one of the major areas of the Should-Cost evaluation that will indicate whether or not the contractor's proposed costs are based on estimates that represent efficient utilization of labor and facilities in manufacturing. As previously mentioned, note should be made that many inadequate business systems will result in inefficiencies of under-utilization of men and machines. Direct labor estimates are also the main basis upon which supporting effort is factored or ratioed and indirect burden is allocated. Thus, the direct labor estimate is highly leveraged.

b. Generally, direct labor can be categorized as fabrication, assembly, and test evaluation. Fabrication can be broadly defined as

h. As previously mentioned, a large part of the Should-Cost effort will be involved in analyzing the direct labor hour estimate that the contractor has based his proposal on. If the contractor has standards and used these standards in the development of his estimate, the analyst should check the standards for validity and their accumulation into the total direct labor hour requirements. If the standards are valid, the contractor should be using them to control his labor force and to schedule his production. If he does not, the standards are probably not valid. If they are not systematically updated reflecting methods and process changes, their accuracy should be doubted. They should be developed by a documented procedure which prescribes how the time measurements will be made and what allowances will be allocated for shift start up, tool changes, machine maintenance, set ups, fatigue, unavoidable delays and personal time. Ratio delay analysis, as described in Chapter 7, should be used to check standards. If this analysis points out that workers are only working 75% of the time and the labor control reports indicates productivity of 95%, the standards are probably too "loose." Allowances should be checked to see that they are not excessive. Fifteen percent total allowance is generally considered a maximum for manufacturing. If time allows and there seems to be significant saving involved, the Should-Cost team may want to establish accurate standards for an appropriate sample of jobs so that statistically supported statements can be made about the contractor's direct labor estimate. Chapter 7 should be reviewed for considerations concerning methods of establishing standards and sample sizes.

- i. When the workers are essentially machine paced, machine utilization should be checked. Ratio delay can also be done for machines as well as people. The Government should not be paying for idle machines; therefore, in conjunction with the documentation of labor productivity, machine utilization should be evaluated.
- j. If the contractor does not have standards and has used historical information or pure estimates to derive his direct labor hours, it will be necessary for the Should-Cost team to arrive at an independent evaluation of the hours required. As the contractor has not based his hours on engineered standards, the Should-Cost evaluation may consider the use of semi-engineered standards. This infers that strict adherence to prescribed industrial engineering methods and principles may not have to be followed.
- k. Another important consideration in the area of manufacturing efficiencies is methods improvements. The Should-Cost team will have to rely heavily on experience in the evaluation of possible methods improvements. However, common sense is not a bad substitute.

## 12. Engineering Resource Control

- a. The importance of this system to the Should-Cost effort will be dependent on the specifics of the contractor's engineering involvement on the particular proposal. When engineering is significant, it should be controlled in the same respect that manufacturing labor is controlled. The outputs of engineering should be considered as their production item to which time elements 'start times, completion times

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and manhours) are assigned as in production scheduling. The development of standards is more difficult in engineering; therefore, supervisor's estimates will often be substituted in the place of standards. The important concept here is that completion goals are assigned to work, and progress is monitored and reported.

b. Findings in this area will be hard to quantify and support. Ratio delay analysis, organizational analysis, and supervisor to worker ratios may prove useful.

### 13. Wage and Salary Control

a. The contractor may use several methods for applying labor rates to direct engineering, tooling, manufacturing and direct support labor. Some contractors present considerable detailed information to support projected wage rates by grades and classifications of direct labor, while others present only data on average rates by function or by plant. The analyst should look for consistency of method. Apparent deviations or special cases that do not adhere to the stated method should be examined carefully.

b. Plant-wide rates are usually found in companies producing a limited number of products (often in large volume) which require application of labor from all the functions or departments. On the other extreme, some contractors apply separate rates for various labor grades and classifications within each department or function. Sometimes an average rate for the department is used. The detailed approach is used most frequently within organizations where different

processes or operations requiring varying degrees of skill exist, where wage rates vary widely, and where the items manufactured do not require contributions by all functions. Where average rates are employed, the analyst should insure that it is properly weighted for the midpoint of effort.

c. For proposal estimating purposes, most contractors forecast wage rates several years into the future. When agreed to by the Government, the forecast rates may be formalized in a forward pricing agreement. The agreement and supporting documentation usually offer the most direct route for the analysis. If the contractor does not have a forward pricing agreement, the difficulty of data gathering will be increased, and the likelihood of finding all the required information is lessened. However, a Should-Cost analysis of labor rates should be undertaken. The forecasted information must be derived from past proposals and historical experience.

d. In developing projected labor rates, contractors ordinarily apply adjusting factors to the latest actual rates regardless of whether these are for individuals, department or function averages, or by separate labor grades and classifications. The kinds of modifying factors applied by contractors probably will include: potential increases or decreases in overtime or shift premium; salary increases (merit increases) for the labor force; cost of living adjustments; provision for reduction of average rates caused by new hires; provision for increase in average rates caused by lay-offs; and changes resulting from

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anticipated union agreement negotiations. These factors must be evaluated for each separate wage rate used by the contractor in the proposal build-up.

14. Data Processing Control

a. With the high operating costs of data processing facilities, it is a must that the equipment be properly utilized and that the reports and information from these facilities be useful. Just as with production equipment, the data processing operations should be planned, scheduled and controlled. However, daily control is appropriate in this area of the contractor's operations. The computer operations should be scheduled and controlled daily. This is also true for the operations that support the computer such as keypunching.

b. Documenting the efficiencies of systems analysts and programmers will be difficult, but their time should be controlled in a similar manner to engineers. A review of systems and programming documentation may indicate the effectiveness of these individuals. If documentation is not complete, proper management is not being exercised.

c. The keypunching operations should be using some form of batch control as discussed in the clerical control section and in Chapter 7.

d. Utilization reports should be reviewed and possibilities of leasing surplus time considered. Off-site file protection should be provided, and a suspense system should be operating to insure timely receipt of data and dispatch of reports.

e. The Government should only pay the properly allocable portion of data processing facilities that are well managed and supply users with timely and useful information.

IV. DD Form 633

1. It is not intended to repeat Armed Services Procurement Regulation (ASPR) provisions but to emphasize the use of the DD 633 Forms in the Should-Cost analysis. The reader should familiarize himself with ASPR 3-807, 16-206, F-200.633 and Appendix A of the ASPR Manual for Contract Pricing, ASPM No. 1. The offeror is required to either furnish, or indicate where it may be found, all cost or pricing data that could be reasonably expected to have a significant effect on price negotiation. This includes not only historical accounting data but also such data as vendor quotations, nonrecurring costs, production methods, changes in production, unit cost trends, make or buy decisions and other management decisions or actions that could be expected to have an effect on costs under the proposed contract.

2. The elements of cost set forth on the DD 633 should be easily related to the elements previously discussed in this chapter. The definitions of the elements on the DD 633 are given in Appendix A of ASPR Manual ASPM No. 1. The cost elements or breakout will vary from offeror to offeror. The contracting officer may waive the DD 633 format so an offeror may furnish cost data in a manner that conforms to his accounting system.

3. The important aspect of the DD 633 in the Should-Cost analysis is the reference column. This covers the identification of supporting data or is otherwise known as the key to trackability of the data. The information provided by the offeror should normally be found as attached schedules. Members of the Should-Cost team should review these schedules and ascertain what specific data should be tracked to the source at the offeror's facilities.

V. Relationship Between 633 Elements and the Elements of Analysis

When inefficiencies are found in the systems and operations of the contractor, the Should-Cost team will have to determine their impact on the 633 cost elements. To facilitate this evaluation, Figure 6-1 is presented to show where inefficiencies in the elements of analysis will most likely effect costs on the 633 form.

**NOTE:** M - Indicates a possible Major cost impact.

m - Indicates a possible Minor cost impact.

FIGURE 6-1

CHAPTER 7

TECHNIQUES FOR QUANTITATIVE EVALUATION

I. Mathematical/Statistical Methods

1. General

The purpose of this section is not to teach mathematics and statistics, but to acquaint or reacquaint the reader with some of the basic mathematical and statistical methods which have and can be used in cost analysis. It should be read primarily by the members of the Should-Cost Team who will be handling the quantitative part of the Should-Cost study, mainly to identify areas with which they should be thoroughly familiar. If the reader is not already familiar with the subject matter in this section, he will not be able to learn it in time to apply it to the numerical analyses required in Should-Cost. But if he has a quantitative background, then he will recognize what is in this section and pursue it in more detail by checking the references indicated in the Should-Cost Library.

2. Sampling Techniques

a. Sampling will be used extensively throughout the Should-Cost study. Since the team has not enough time to check every single item of interest, they will be required to rely heavily upon samples taken from each major field of interest. These samples should be representative of what is being investigated, and should be large enough to give the required level of confidence to what is being estimated. The results of the analysis taken from these samples

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must stand up under negotiation. Sampling will be used in all three areas of investigation: that is, in production, management and auditing. There are basically two methods of sampling: random and systematic. Simple random sampling refers to a sample selected from a population in a manner such that each combination of a given number of items has the same chance or probability of being selected as every other combination. In systematic sampling, units are selected from the population at uniform intervals of time, space, or order of occurrence; i.e. a sample is obtained by selecting every  $k$ th item on a list, every  $k$ th voucher in a file, every  $k$ th piece coming off an assembly line, etc. An element of randomness may be introduced by randomly selecting the  $k$ th unit from which to start. A disadvantage to systematic sampling, however, is that if any bias is present in the units to be sampled, a bad sample may result.

b. There are three factors affecting a sampling design:  
(1) whether a population is homogeneous (if all the units in the population are governed by the same set of causes), (2) the degree of precision and confidence required, and (3) the cost of the sampling plan.

c. A random sample is appropriate for a homogeneous population. The problem of achieving randomness can be solved by the use of a table of random numbers. However, if some information concerning the population is known, it may be better to divide the population into groups such that elements within each group are more alike than are the elements in the population as a whole. If a simple random sample is

drawn separately from within each group then the desired representation from each group is insured and the element of chance is still present in our sample. Whenever a population is divided into groups, and a random sample is taken in each group, the sample is called a stratified sample. The groups from which the sample is drawn is called the strata, and the process of dividing the population into groups is called stratification. Hence, the technique known as stratified random sampling. This technique is probably the one most used in the Should-Cost studies, since it guarantees that population subdivisions of interest are represented in the sample, and hence improves the precision of whatever estimates are to be made from the sample data. For example, auditors may divide items in the population into high and low dollar-value items, or some such similar categories. Random samples are then selected from each category or strata. To insure that each item has the same chance of occurring as any other item, a table of random numbers may be used, or a random number sub-routine in the computer.

d. Another technique known as cluster sampling is sometimes used in auditing and in manufacturing process control. It is a method of sampling in which the elements of a population are arranged in groups (or clusters); some of the clusters are then selected randomly or systematically, and the ones chosen are then subsampled, or surveyed 100 per cent. An example would be the inspection of n consecutive items at intervals of approximately one hour as they may come off an assembly line. Another example can be drawn from the area of accounts receivable. Suppose that individual accounts are filed in trays, and that a group of

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trays constitute a ledger, with the total of all ledgers tying into the general ledger control over receivables. A useful design is to treat the population as being composed of a series of trays which represent "clusters" of receivables. The sample may then be chosen by selecting a number of trays of receivables for individual analysis.

e. Another sampling procedure which was initially created for quality control purposes in the production field but is now used in accounting and other areas is acceptance sampling. Acceptance sampling has a decision rule associated with it, which indicates when a particular lot should be accepted (when it meets quality standards), or rejected (when it does not meet the quality standards). The decision rule is simply a specified number of defectives, called the acceptance number. If the number of defectives is less than the acceptance number then accept the lot, if greater than then reject the lot, if equal to, then a decision must be made whether to continue sampling. An acceptance sampling plan consists of a sample size number, an acceptance number, and a procedure for drawing the sample. (See the text Sampling Inspection Tables by Dodge and Romig, Wiley.)

f. Of course, there exist more complex sample designs which may be found in texts such as Sampling Techniques by Cochran and Sample Design in Business by Deming. What has been mentioned is basic and any combinations of these methods along with various estimating procedures yet to be mentioned, are generally used for any one sampling problem. Attention should be paid to the DCAA programs in the "should-Cost Library on sampling; in particular the routines, RANUM, RASEQ,

SAMSI, and APSAM. The formulas for the appropriate sample sizes may be found in paragraphs 6 f, g and i, which have to do with estimation.

### 3. Probability Distribution

a. There are several probability distributions with whose characteristics the analyst should be thoroughly familiar. These distributions appear over and over again in cost estimating, industrial engineering methods, operation research and management science. It is important to be able to recognize them so as to use the appropriate tests to estimate their parameters and to calculate the probability of occurrence of certain pertinent random variables belonging to the distributions. Those which are most frequently encountered will be mentioned in this Guide.

b. Binomial Distribution. The binomial distribution describes discrete data of the two-possibility type, such as yes-no, either-or, accept-reject, success-failure. These two possible outcomes are statistically independent and have well defined probabilities associated with them. These probabilities remain the same for each trial for which these possible outcomes may occur. The binomial is used in work sampling studies such as the ratio-delay, in quality control, and is the distribution used to estimate the parameter of a distribution of proportions or percentages.

#### c. Normal Distribution

(1) The normal distribution is the most frequently used

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distribution in statistics. It is a bell-shaped curve which has two identifying parameters, the mean and the standard deviation. The shape of the curve is such that approximately 68% of its area is within  $\pm 1$  standard deviation from the mean, and 95% is within  $\pm 2$  standard deviations. It is the limit of the binomial distribution as  $n$  becomes large, and as such, it serves as a useful approximation to the binomial distribution. It is used in this capacity in the work sampling studies. Also there are certain statistics, such as the arithmetic mean, which tend to be normally distributed as the sample size increases. Hence, if samples of size  $n$  greater than or equal to 30 are drawn from a population that is not normally distributed, the distribution of the sample means is approximately normal. The number 30 is chosen since the distribution of the sample means from samples of this size or greater closely approximate the normal distribution. That is not to say that if  $n$  is less than 30 the normal distribution may not be assumed, but it would be better then to ascertain normality.

(2) A way of ascertaining whether the normal curve is the appropriate one to fit a frequency distribution may be done by plotting the data on probability graph paper. The data is cumulated and percentage frequencies calculated and plotted on the probability graph paper. If the distribution is normal, the curve is a straight line. If the distribution is positively skewed, the curve tends to be concave from below at the lower end. If the distribution is negatively skewed, the curve tends to be concave from above at the upper end.

d. Student - t Distribution. The t-distribution is a bell-shaped curve like the normal. It is used largely for inferences concerning the mean (or means) of normal distributions whose variances are unknown. It is used instead of the normal when  $n$  is less than 30, and hence is often referred to as small sampling theory. However, it may be used for large or small samples, and should really be referred to as exact sampling theory. It should be used instead of the normal whenever the population variance is unknown and hence the sample variance must be used in place of it.

e. Poisson Distribution. The poisson distribution is a discrete distribution like the binomial. The poisson is referred to as the limiting form of the binomial since it is derived from the binomial when the probability of an occurrence on a single trial grows smaller, the number of trials grow larger, and the product of the two are relatively constant. In general, it is found that the Poisson distribution gives a more accurate measure of probability for some events which have a small probability of occurring, than does the binomial. A rule of thumb for determining when to use the poisson instead of the binomial is when the product  $np$ , where  $n$  is the sample size and  $p$  is the probability of occurrence, is less than ten. The poisson distribution is frequently useful, in the application of statistics to accounting and auditing, in those situations where the sample size is small in relation to the total population, and the assumed error rate is relatively low. The poisson distribution is also used extensively in "waiting line" theory since arrival rates follow a poisson.

4. Tests of Hypotheses

a. Now that something has been said about sampling and distributions, the topic of testing hypotheses should be mentioned. A statistical hypothesis is something which is said about a population. It usually has to do with making certain assertions about the parameters of these populations. It may be based on assumptions about the population, or it may be based on empirical evidence, or both. A statistical test is devised to determine whether to "accept" or "reject" the stated hypothesis. For example, it is often necessary to test the claims made by a contractor as to his expected costs, expected labor hours, or expected labor standards, etc. It may not be possible to check every element of a population; therefore, a random sample may be taken and used to test whether the stated parameter of the population is correct or not. The method of the test is designed so as to give the facts of the sample an opportunity to discredit the hypothesis.

b. Tests of hypotheses are based on evaluating the probability of occurrence of the observed sample given the assumption that the hypothesis is true. If the observed sample is very unlikely to occur if the hypothesis is true, then the hypothesis is rejected. But, if the observed sample is expected to occur if the hypothesis is true, then it is not rejected. Hence, a decision is being made about the population based upon the information obtained from the sample. Because of sampling variation, it is not possible to be sure that the decision made about the hypothesis is correct in any specific case;

but, the decision is made and the appropriate action taken. The question is then asked, "What if the wrong decision is made?"

c. There are statistical errors associated with the rejection or acceptance of a hypothesis which may be controlled. They are controlled by the sampling procedure and by the size of the sample. The probability of rejecting a hypothesis given that it is true, is called the type I error. The Greek letter " $\alpha$ " is often used to designate this error. It is also sometimes referred to as the producer's risk. The probability of accepting the hypothesis given that it is false is called the type II error. It is denoted by the Greek letter " $\beta$ ", and is often referred to as the consumer's risk. If  $\alpha$  is decreased then  $\beta$  is increased. The only way both errors are decreased is to increase the sample size. Although it can never be ascertained in a given instance whether an error of either kind is made, the probability of making either type of error can be determined. See AMC Engineering Design Handbook, Section I, p.3-1, and also Schaum's Chapter 10, in the Should-Cost Library.

d. The simplest form of the test is the one sample test. The procedure is to take a sample, find the sample mean and the sample standard deviation, and compare it to the expected value, i.e., the mean value, claimed by the contractor to be the true parameter of the population. For example, suppose the contractor was buying certain items to use in the manufacture of his product. He claims that the average price paid for these items did not differ by as much as 10% from the lowest current cataloged price. Since the Should Cost team

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is concerned that the contractor may be paying more than 10% of the lowest current cataloged price his hypothesis is then tested. A sample of the items bought during the last year is taken and statistically analysed to see whether there is any reason to doubt the contractor's claim. An  $\alpha$ -level is picked (usually  $\alpha = .10$ ,  $\alpha = .05$ , or  $\alpha = .01$ ) and if the value obtained by the test exceeds a tabulated value the claimed or hypothesized value is rejected. The  $\alpha$ -level is the probability of detecting a significant difference when there is none, or the type I error. When the hypothesized value is accepted, then a type II error can be made, that is the probability of not detecting a difference when one does exist. This probability can be calculated or it can be read from an OC curve. Several of these curves can be found in Chapter 3, Section I, of the AMC Engineering Design Handbook. The required sample size necessary for a particular  $\alpha$  and  $\beta$  may also be obtained from these curves. An example of this procedure is found in pages 3-4, Section I, of the AMC Engineering Handbook. If the OC curves are not available the following formula may be used to determine the sample size necessary for the required  $\alpha$  and  $\beta$  levels (producer's and consumer's risk).

$$n = \frac{(z_\alpha - z_\beta)^2 \sigma^2}{(\mu_a - \mu_0)^2}$$

Where  $z_\alpha$  and  $z_\beta$  are values obtained from the standard normal distribution table;  $\sigma^2$  is the variance of the distribution being tested; and  $(\mu_a - \mu_0)$  is the difference which the test wants to be able to detect with error

levels of  $\alpha$  and  $\beta$ .  $\mu_0$  may be the expected value claimed by the team. The sample size will generally not turn out to be an integer, so in most cases it will be best to round the calculated sample size to the next largest integer.

e. Some short-cut tests for comparing an average also exist and may be found in Chapter 15, Section IV of the AMC Engineering Handbook. The statistical efficiency placed in these short-cut tests are not as great as in the one stated earlier. The short-cut tests can be used as a quick estimate for further exploration.

f. To test a hypothesized percentage or proportion check Chapter 8 of AMC Engineering Design Handbook, Section II. The  $\alpha$  and  $\beta$  errors are discussed along with the required sample sizes for making the tests of hypotheses.

h. It is also important to compare two observed proportions or percentages for significant differences. Again sample size is important not only in controlling the type I and II errors but in the way the significance tests are handled for large versus small samples. See pages 8-9 through 8-21 in Chapter 8 of AMC Engineering Design Handbook, Section II.

5. Analysis of Variance. Sometimes it is necessary to deal with more than two populations. For instance, in those Should Cost studies where chemical processes are being investigated (ammunition plants may fall into this category) it may be important to review process controls to check the costs for transference and distilling

of the water associated with the acids being used. Sometimes three, four or more production lines or processes may need to be tested for variability with regards to cost or simple quality control. In instances where a significant difference is looked for between more than two populations, the analysis of variance techniques and multiple comparison tests should be used. It may be better to consult with a statistician before the tests are conducted to insure that the proper design is used and the correct hypothesis tested. Refer to Section III of the AMC Engineering Design Handbook. Also the following tests may be helpful: Fundamental Concepts in the Design of Experiments by Charles R. Hicks; The Design and Analysis of Industrial Experiments by O.L. Davies; and Simultaneous Statistical Inference by Rupert G. Miller

## 6. Confidence Intervals

a. One of the reasons for using statistical analysis is to estimate the value of a population parameter from information contained in a sample drawn from that population. For example, to estimate the mean of a population a random sample is drawn from that population and the sample mean can be used as an estimate for the population mean. This is called a point estimate, and clearly it is either right or wrong. This point estimate will also more than likely change from sample to sample. Therefore it would be better to estimate the parameter by catching it in an interval. By using intervals, the estimates can be evaluated in terms of probabilities. Hence, the procedure used is to compute an interval in which the parameter is estimated to lie, called a confidence interval. The degree of confidence that this

interval includes the true parameter is not associated with this particular interval but with the method used to calculate the interval. Therefore, the degree of confidence that an interval contains the true parameter is numerically equal to the percentage of such intervals, if many were computed in exactly the same way, which may be expected to include the parameter. Hence a computed interval may or may not include the true parameter; but the procedure will eventually yield a known percentage of intervals which do include the true parameter. This percentage is known as the confidence level or confidence coefficient. So when a 95% confidence interval is found, it means that 95% of the intervals using this statistical procedure contain the true parameter. The repetitive statistical procedure is the sampling. As an example, suppose the Should Cost team wanted to estimate what they thought the direct engineering labor-hours for a particular contract should be. It is not possible to estimate the entire population so a properly chosen sample is taken. The requirements are that the confidence level of the confidence interval on the estimate must be 95%. A sample size is determined which would insure a 95% confidence level for the interval of estimation. This means that 95% of the samples of this particular size would give us an interval which includes the parameter, direct engineering labor hours, and only 5% of the samples drawn would not. Hence, the odds are well in favor of the interval containing the true parameter. More about the explanation of confidence intervals, may be found in the AMC Engineering Design Handbook, Section I, pp. 1-11 through 1-15, and in Chapter 9, p. 156-166 in Schaum's Statistical Outline.

b. Confidence Intervals about the mean,  $\mu$ . The procedure needed to actually calculate a confidence interval about the population mean will not be included in the guide but may be found on pages 2-1 through 2-15 in Section I, of the AMC Engineering Design Handbook. Both the two-sided and one-sided confidence intervals, when knowledge of the variability of the population is assumed and when it is not, are discussed in these pages.

c. Confidence Interval Estimates of the True Proportion,  $P$ . It may be desirable to obtain a confidence interval about a proportion or percentage of items that have a given quality characteristic such as a percentage of labor hours, or the proportion of defective items in a sample, or the proportion of bad accounts receivable. The procedure for the computation of both these two-sided and one-sided confidence intervals of a proportion can be found on p. 7-1 through 7-6, Section II of AMC Engineering Design Handbook, along with tables and Clopper-Pearson Charts in Section V of the Handbook.

d. Another type of sample estimate which is frequently encountered in accounting situations is the ratio estimate. The ratio estimate technique is used extensively in such areas as: ratio of current prices to base prices in a cost index; ratios of dollars of accounts receivable in a particular age category to total dollars of accounts receivable; and ratios of dollar error in account balances to total dollar account balances. The ratio estimate is similar to the estimate of a proportion, except that a ratio has a random variable in both the numerator and denominator whereas a proportion has a random

variable in the numerator and a fixed number (sample size) in the denominator. To illustrate this difference, suppose a sample of 50 accounts is selected to determine the proportion of accounts in error. The denominator is 50, the numerator is not known before examination; it is a random variable. However, if a sample of 50 accounts is selected to estimate the ratio of dollar error to total dollars, then neither numerator or denominator are known before examination, and hence both are random variables.

e. Sample size is again important in estimation to insure the required confidence level. The DCAA program library has two routines which estimate sample size to permit the auditor to obtain specific confidence intervals while examining a minimum total number of transactions. The names of these routines are SAMSI and APSAM.

f. The formula to determine the required sample size for the confidence interval about the mean of a population is:

$$n = \frac{z_{\alpha/2}^2 \sigma^2}{e^2}$$

where  $z_{\alpha/2}$  is associated with the risk  $\alpha$ , and obtained from the standard normal tables;  $\sigma^2$  is the variance; and  $e$  is the error allowed between what is the true parameter value and what we estimate it to be.

g. The formula to determine the sample size required to estimate the confidence interval of the true proportion, P, within an error e is

$$n = \frac{z^2 p(1-p)}{\alpha/2} \cdot \frac{\alpha/2}{e^2}$$

This sample of size n gives a probability not greater than d that the estimate of P is in error by not more than e. The values used for p are the best estimates gained from any prior information. If no prior information about P is available then the formula simplifies to

$$n = \frac{z^2}{\alpha/2} \cdot \frac{\alpha/2}{4e^2}$$

h. The procedures that have been discussed so far with respect to confidence intervals have been under the assumption that the random samples have been drawn from an infinite population. If the population is finite and our sample is small relative to the size of the population, the techniques mentioned are still appropriate. The question is then asked, "How small is small?" A general rule of thumb is when the sample size is less than 5 per cent of the population. When the sample size is greater than 5 per cent of the population a new factor must be applied to the standard errors of the sample statistics, called the finite multiplier,  $\frac{N-n}{N-1}$ , where N

is the size of the population and  $n$  the size of the sample. This quantity, the finite multiplier, is approximately equal to the proportion of the population not included in the sample. When the population size is sufficiently large so that  $N-1$  is proportionally very close to  $N$  (this is almost always the case) then it is represented adequately by the expression  $(N-n)/N$  or  $(1-\frac{n}{N})$ . The reason for the modification lies in the fact that the variances or the standard errors of sample statistics tend to be smaller as the sample becomes a sizeable proportion, i.e., more than 5 per cent of the population. See equation (1) on p. 142 and equations (2) and (4) on p. 158 of Schaum's Statistical Outline.

i. The formula to determine the sample size required to give a 95% confidence interval about the true proportion of a population when the population is finite is

$$n = \frac{N}{1+Ne^2}$$

where  $N$  is the number of elements in the population and  $e$  is the error allowed for deviation.

7. Chi-Square Tests. The chi-square test can be used to test many different kinds of hypotheses about frequencies or percentages. It can compare observed frequencies in order to determine whether the differences are significant, that is, too great to be attributable to chance. It can be used as a goodness of fit test, so as to test

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whether the distribution from which the data came is binomial, normal, uniform, or some other distribution. It can also be used to test the independence of principles of classification, that is, it involves making a decision as to whether a set of classification criteria is meaningful or effective. A table which presents the data classified on the basis of two principles of classification is called a contingency table. For more information on chi-square tests and examples of how they may be used check Chapter 12 of Schaum's and Chapter 9 of the AMC Engineering Design Handbook, Section II.

#### 8. Curve Fitting.

- a. In the Should-Cost studies, in cost analysis, or in the general study of economics it is important to identify relationships between economic variables, i.e., to see if any cause and effect relationship exists between two or more variables. For example, quantity demanded may be regarded as a function of price, disposable income, and prices of related items; production costs will depend on rate of production, factor prices, and changes in production rate; support labor may be related to total workforce, workload, or work effect with respect to time.
- b. One variable is taken as the independent and the second as the dependent, then values are assigned to the independent variable while observing the outcome of the dependent variable. The observed values are plotted on a coordinate system and the resulting figure is called a scatter or dot diagram. The horizontal axis of the coordinate system is used for the independent variable (such as units or production)

and the vertical axis is the dependent variable (such as man-hours or costs). The relationship between variables may be linear or non-linear and this should be shown by the scatter diagram. If the relationship is linear the points will approximate a straight line, but if non-linear the points will approximate a curve or exhibit no geometrical relationship at all. Examples of these diagrams may be found in Chapter 13 of Schaum's. No exact relationship between the two variables may exist, but in general as the independent variable changes the dependent variable does also. Hence the object of this curve fitting is to determine the best mathematical function to explain the observed values. The mathematical function may be simply a linear equation such as  $\hat{Y} = a+bx$ .  $\hat{Y}$  is used instead of  $Y$ , to show that it is the value on the fitted line and not the observed value. The coefficients  $a$  and  $b$  are unknown and must be estimated. This idea may be better explained by the following example. Suppose it might be necessary to establish a Should-Cost position for Manufacturing Overhead Materials, which consist of small tools, supplies, hardware, fuels and miscellaneous store commodities used to support and maintain personnel, plant building, manufacturing and plant transportation facilities. The contractor's dollar projections and rationale are examined and compared with a pattern that such costs might normally follow. The results show that 25% of such historical costs are related to employment levels and 75% contain charges that are nonrecurring in nature. For those costs hypothesized to be related to employment levels a simple linear model is developed using historical data. The

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data consists of total plant personnel as the independent variable (horizontal axis) and manufacturing overhead materials costs as the dependent variable (vertical axis). The following Figure 7-1 illustrates the problem:

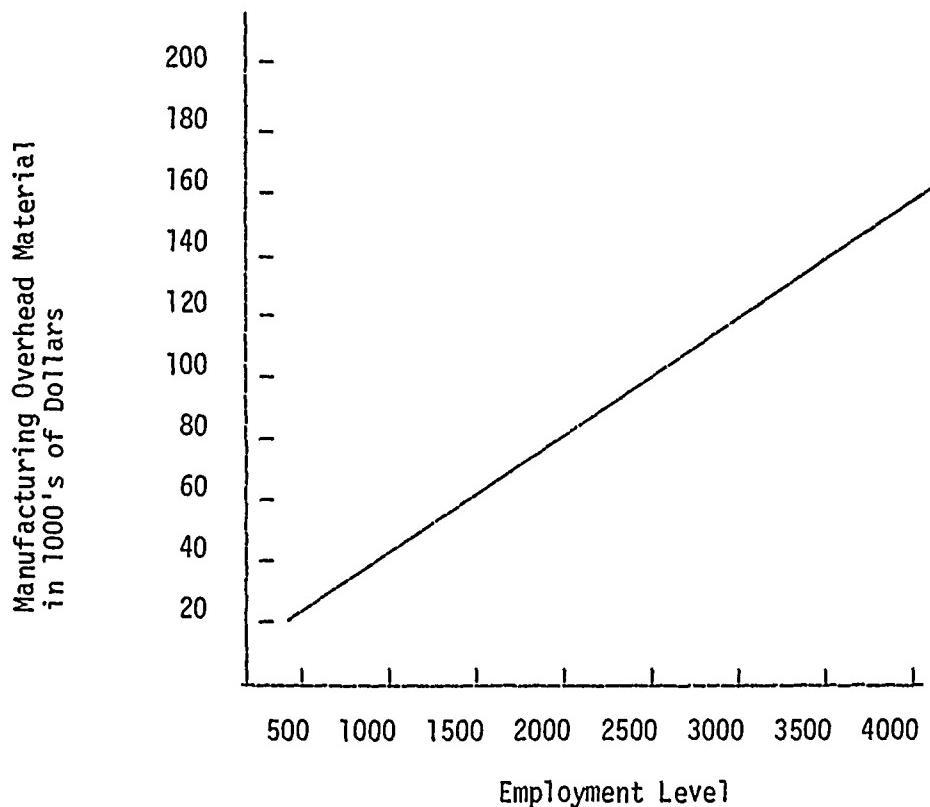


Figure 7-1

The equation of the trend line is estimated to be  $\hat{Y} = 15,000 + .04x$ . Hence, 25% of the contractor's manufacturing overhead material may be expected to follow this trend and hence be estimated from this line.

c. Three methods most commonly used to fit a straight line to data are: the method of selected points, the method of averages, and the method of least squares. Individual judgment can also often be used to draw an approximating curve to fit a set of data. This is called a freehand method of curve fitting. The method which gives the best fit to a curve is the method of least squares. This method should be used in the Should-Cost studies, since although there are more calculations involved the fit is more accurate. These calculations need not be done by hand since there are excellent subroutines to do this in the DCAA computer library; check routines ICLOT, ICUNI, ICPRO, CALOT, CAUNI, and CAPRO. Also refer to Chapter 13 of Schaum's for a detailed explanation of the method of least squares with respect to linear and non-linear relationships, and also Chapters 5 and 6 in Section I of the AMC Engineering Handbook. It is recommended that Chapter 17 of the handbook also be read to deal with the treatment of outliers in rejecting observations when fitting curves to data.

#### 9. Regression and Correlation Analysis.

a. The previous section had to do with projecting a trend of related pieces of information. There was no mention of prediction of a parameter in a confidence interval with a stated confidence level, that is, the degree to which we would rely on this predicted trend. But the analyst would like to know the quality of his estimates in order to predict unknown parameters with some degree of confidence, and hence the reliability of the trend. The following questions must be answered before this can be done. First, how

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closely can the values of the dependent variables be estimated from the values of the independent variables? Second, how important is the relationship between the dependent variable to the independent variables? Finally, how much will the answers to the first two questions increase our confidence in the sample used to estimate the parameters of our trend line? Special statistical devices employed in the methods of regression and correlation analysis answer the above questions.

b. Correlation Analysis is the analysis of paired data constituting the values of two random variables X and Y. It is used to see if any mathematical relationship (association or dependence) between two or more qualitative or quantitative variables exist. Regression Analysis is the analysis of the paired data after a mathematical relationship as been determined to exist. Then the X is fixed and treated as a constant and the Y is treated as a random variable. In essence, correlation analysis is used to verify an assumption of causal relationship between two pieces of random data; and then fixing one of the variables as a constant, a regression line or curve is fitted to estimate the parameters of the population from which the sample of data was drawn. This is not much different than what was done in the last section in curve fitting. But now several further assumptions are made about the random variable. It is assumed to be independent and normally distributed with a mean equal to  $A + BX$  and a variance of  $\sigma^2$ . As soon as these assumptions are verified then the equation for the straight line fitted to the data can be used to predict with some degree of confidence what to expect

the dependent variable (random variable) to be, given the independent variable (that which is fixed). Correlation and Regression Analysis can be useful, in the context of the Should Cost study, to estimate the parameters of cost improvement curves and learning curves or to develop independent projections of rates and factors used within the proposal price build-up. But it must be used wisely and correctly.

c. The estimate of the variance,  $\sigma^2$ , is important since it is used to measure the degree of concentration (dispersion) of the observations about the regression line. The formula used to calculate the variance is found on p. 243 (equation 10) of Schaum's in the Should-Cost Library. The square root of the variance is called the standard error of estimate and is a term frequently mentioned in regression.

d. Another mathematical expression which shows the fit of the data to the regression line is defined as the coefficient of determination, and is denoted in the texts as  $r^2$ ; its formula can be found on p. 243 of Schaum's. This expression shows the relative reduction in the total error when a regression line is fitted, that is, the amount of variation explained by the regression line with respect to the data. The maximum value for  $r^2$  is one which occurs when the observed Y values fall exactly on the regression line,  $\hat{Y} = a + bx$ . When this happens, the regression line is said to perfectly fit the data, but this is rarely known to happen. The minimum value for  $r^2$  is zero, and this occurs when there is no linear relationship at all between the independent variable X and the dependable variable Y.

Therefore,  $r^2$  may take on any value between zero and one. Hence the amount of improvement (in terms of reducing the total error) brought about by fitting the regression line is indicated by  $r^2$ ; and the closer  $r^2$  is to one, the better the fit of the line to the data.

e. The square root of the coefficient of determination is the correlation coefficient, denoted by  $r$ . The statistic  $r$  lies in the interval from minus one to plus one,  $-1 \leq r \leq 1$ . The plus or minus sign, before the value of  $r$ , indicates whether the slope of the regression line is positive or negative, respectively. Hence the correlation coefficient is a measure of linearity between  $X$  and  $Y$ . If the regression line has a positive slope then  $Y$  increases with  $X$ ; but if the regression line has a negative slope then  $Y$  decreases as  $X$  increases. If  $r = 0$  then there is no slope, that is, there exists a straight horizontal line for which a change in  $X$  causes no change in  $Y$ . The formula best known to compute  $r$  is the Pearson Product-Moment Formula; equation 20, p. 245 in Schaum's.

f. After computing the coefficient of correlation,  $r$ , it can be determined whether a significant relationship actually exists between the variables  $X$  and  $Y$  by comparing the computed value against the appropriate value in a significance table. A significance test may also be used to estimate the probability that the coefficient could have been obtained by chance from a population with a true coefficient of correlation of zero. The test is made by computing a "t" value and comparing it to the "t" value with  $n-2$  degrees of

freedom in a table. The formula for the computed "t" value is equation 28, p. 247, in Schaum's.

g. It should be kept in mind that the interpretation of a correlation coefficient as a measure of linear relationship is a mathematical interpretation and is completely devoid of any cause and effect implications. Correlation coefficients must be handled with care if they are to give sensible information concerning relationships between pairs of variables. It is not possible to set minimum levels for the coefficient of determination (or correlation) since each result must be considered in light of the factors and conditions of the particular study. But if  $r^2$  is smaller than was expected, the following steps may be considered as guidelines:

(1) Re-examine the data for heterogeneity. This is often spotted in a scatter diagram as a tendency for the plotted values to cluster into two or more groups. To correct this, stratify or reclassify the data on some rational basis and then correlate each group separately. Individual items that are clearly governed by a different set of causes should be eliminated.

(2) Re-examine the data for a non-linear relationship. Recall that  $r$  measures linearity between two variables. The true model may be curvilinear.

(3) Check the proposed model for the presence or absence of additional significant variables.

(4) Note the size of the variance. In fact, the model

should always be re-examined whenever the variance is very large, even if  $r^2$  is close to one. (See section 1.5 in the text, Applied Regression Analysis by Draper and Smith and p. 5-22, Section I of the AMC Engineering Design Handbook.)

h. Confidence intervals may be found for the parameter the expected value of Y for a given X on the true regression line, for a particular observed Y, and for the slope B and intercept A. Tests of significance may also be made on B and A. For more detailed information on simple linear regression and also multiple linear and curvilinear regression, see Section I, Chapters 5 and 6, AMC Engineering Design Handbook and Schaum's Chapters 14 and 15. For the use of the computer in simple linear, curvilinear, and multiple linear regression, see the DCAA computer programs in the library, in particular CURFI, MULFI, and MULFIT.

#### 10. Learning Curves

a. The learning curve method is a widely used and accepted technique in both industry and government for estimating the effect of quantity increases on production costs. Historically, the term "learning curve" was adopted from the recognized fact that when a task is repeated over and over again, the individual repeating this task tends to do it more efficiently each time. Therefore the cost of manufacturing an item will decrease as the number of items produced is increased. Specifically, the learning curve concept stipulates that the time to perform a function will decrease by a constant percent as the frequency of the function is doubled. When used to describe the

learning phenomenon, this curve is known as progress curve, experience curve, improvement curve, learning curve, and others. The mathematical expression for this curve is given by the equation.

$$Y = AX^{-B}$$

where  $Y$  is the cumulative average value of  $X$  units

$A$  is a constant depicting the value of the first unit  
(it may be theoretical or estimated)

$B$  is an exponent representing the slope or constant relationship between cumulative average cost and units produced (it is usually estimated)

$X$  is the number of units produced

b. If the logarithms of both sides of the equations are taken then the equation is

$$\log Y = \log A - B \log X$$

and when this is plotted on log-log paper it plots as a straight line. The method of least squares is used to determine the equation which best fits the data of the learning experience.

c. There are different factors which influence the learning curve. Often the idea is conveyed that learning represents only the progress made by the production worker in manufacturing one product, but in fact learning is accomplished through many factors. The following are some factors which influence learning:

- (1) Stabilization of design
- (2) Improvement in special tooling
- (3) Improved worker proficiency

- (4) Increase in lot size
- (5) Reduction in scrap, rework, and extra costs
- (6) An adequate cost reduction and value analysis program
- (7) How well the product was researched and engineered before starting production.

d. Great emphasis is often placed upon the steepness of the curve and hence the learning rate as a means of judging one manufacturer against another. The wrong conclusion may be inferred unless the analyst is aware of the extent to which the above factors influenced the results. Where one manufacturer may show real progress after a poor job of initial planning, another manufacturer might do an excellent job of stabilizing the design, training employees, improving the tooling, etc., before producing the first product. The results attained by the latter manufacturer would look poor in contrast to the former if the learning rate were the only factor by which to judge them.

e. There are several different kinds of learning curves and tables in use and the analyst should know which one he is using. There are several learning curve tables in the Should-Cost Library along with the test, "How to Use the Learning Curve" by Raymond Jordon. Also see the DCAA report on Improvement Curve Experience, which should be most useful in any Should-Cost Analysis.

## II. Industrial Engineering

### 1. General

a. Industrial engineering can be defined as the application

of engineering principles and the techniques of scientific management to the maintenance of a high level of productivity at optimum costs in industrial enterprises. In order to achieve this goal, many techniques have been developed by industrial engineers to study industrial scheduling and work processes. Those techniques which are utilized to measure quantity of work to be produced and to establish standard times for work performance are extremely valuable to the Should-Cost team.

2. Work Measurement

a. Work measurement is the appraisal or dimensioning of work in terms of time, thus creating a time standard for performing work under certain specified conditions of measurement (i.e., methods, tools and equipment, training, quality, and performance); and the development of an appropriate information system to use the measurement data. The specific objectives of work measurement are to provide quantitative data that can be used to set schedules and program activities, determine operating effectiveness, compare methods, set labor standards, determine equipment and labor requirements, and of special importance to Should-Cost teams, determine standard costs.

b. There are two classifications of measurement standards--engineered and non-engineered. Because of its make-up and development, an engineered standard is considered the most reliable. It consists of:

(1) A definition of standard time. There must be a written definition of what is considered a standard throughout the

jurisdiction of the work measurement program.

(2) A record of method. This should contain specific statements describing the work situation and method which provide the basis for the standard time and clearly identifies the unit of work measurement.

(3) A record of observed or synthesized time values. These time values used in determining the final standard time may have been derived from stop watch study, film analysis sampling study, or standard data table.

(4) Computations. A record of the computations used to establish the statistical reliability of the standard and a statement of the statistical reliability.

(5) A record of rating as leveling. This is basically a comparison of the observed operator pace compared to the analyst's concept of normal as described in the definition of standard time.

(6) Allowances. What allowances were used for fatigue, unavoidable delays, personal time, etc.

(7) Development of standard. A record of how the standard time was computed showing step-by-step each computation.

c. If a standard does not meet the above criteria it is referred to as non-engineered.

d. Engineered standards are, because of their quality, expensive to develop and maintain. It is possible that for purposes of Should-Cost the cost of development of engineered standards may far outweigh the anticipated gains from their accuracy and reliability.

e. Generally, each manufacturer or organization will have a specific definition of standard time which will meet their specific requirements. An engineered standard is defined in AR 1-50, Work Measurement, Apr 67, as the "the time it should take a trained worker... working at a normal pace to produce a described unit of work of an acceptable quality according to a specified method under specific working conditions."

f. This definition gives rise to the term "Normal Pace." Normal pace is defined as some fraction of the maximum pace that can be maintained on the job, day after day, without physical harmful effects on the operator.

g. To set a standard time, the work activity has to be measured. Some of the methods are rather precise and exact; others less accurate, have great advantage because of ease of application. The method of setting standards are:

- (1) time study,
- (2) work sampling
- (3) predetermined time systems
- (4) standard data
- (5) technical estimates
- (6) historical (statistical) standards, and
- (7) staffing patterns.

h. Time study refers to studies conducted at the work site in which recorded time values are obtained from direct observation with the aid of a timing device. The trained observer must have an

opportunity to observe an individual job actually being performed by a definite method (preferably a method that has been studied and improved). This type of standard is generally considered a valid and reliable basis for the establishment of time standards. Because the method, quality, working conditions, and operator performance are highly standardized, it is easy to identify a deviation from standard and to assign a cause for the deviation. The advantages of time study result from detailed methods descriptions, accurate measurement of work and actual worker observations. The disadvantages are that this method is time consuming and that the pace rating is subjective.

i. Work sampling involves recording a series of randomly spaced observations of a task and synthesizing the obtained data into a standard time. It may or may not yield an engineered standard depending on how the study is conducted. In work sampling, the work must be broken down into categories of work or non-work and their characteristics described; at random intervals the activity is observed and classified by job category; the performance of the operator is compared to the concept of normal (pace rated) and allowances given for personal and unavoidable delays. During the period the job is being observed, a production count must be obtained and the total time of the study recorded. With this information, the allowed time for the various units of production can be obtained. Work sampling is usually used to measure activities which are impractical or costly to measure by other means. A work sampling study usually requires less time and is generally less costly than a time study. However,

work sampling is not generally economical for studying a single operator; methods control is not as precise as time study; and operators may change work patterns without being observed.

j. Predetermined time (PDT) systems are a series of specific techniques which are based upon a very detailed breakout of fundamental hand and body motions to which time values have been assigned. The person developing the standard must be completely familiar with the predetermined time system in use and be able to identify motions pertinent to job being studied. Here the job must be broken into basic motions of the PDT. A few of the better known ones are the Work Factor System (WOFAC) developed in 1938, Methods Time Measurement (MTM) developed by H.B. Maynard, and the Methods Council in 1948, Basic Motion Time-study (BMT) in 1950, and several others. MTM seems to have gained the widest acceptance.

k. The type of standard which most cost estimators use is that established from standard data. Standard data is a collection of time values in the form of tables, charts, or formulae in units of work. The chart or curve is developed from many time studies and observations over a long time period. The application of standard data gives more consistency between jobs and, if the data is in small enough detail, can be used to compare methods. Standard data can be used to develop a standard time prior to performing the job. The time to build up standard data and the cost to collect the data are the main disadvantages of this system.

1. The two most common methods of setting non-engineered standards include technical estimates and historical data.

(1) Technical estimates are non-engineered type standards developed usually without the aid of a timing device or sampling technique. They are usually made by a person technically qualified in certain areas and based on a procedure which breaks the estimate into a series of individual estimates summarized to obtain a standard time.

(2) Historical standards are developed by a statistical or mathematical analysis of historical data where labor expenditures can be correlated with a measure of output. This technique is widely used, and often perpetuates past inefficiencies.

m. Figure 7-2 is a summary of work measurement techniques and their application. In addition to their use in setting standards, some of the above described techniques are directly applicable to Should-Cost studies. These are described in the following paragraphs.

3. Work Sampling/Ratio Delay

a. One of the more useful techniques developed by industrial engineers for improving productivity is sampling work habits, or work sampling. Ratio delay is one of the most direct and uncomplicated forms of work sampling. Ratio delay consists of making observations at random times of a particular work area or department. At the time of observation the observer notes how many people in the area are working and how many are not. He then records his counts. Whereas

## WORK MEASUREMENT TECHNIQUES AND THEIR APPLICATION

Techniques	Types of Operations	Examples of Operations	Application of Techniques
1. Time Study	a. Repetitive, short cycle work performed at essentially one work station.	Parts assembly, machining packaging, typing, filing, editing, packing.	<p>Conduct detailed methods study. Establish elements to be timed. Record time with stop watch or camera (micro-motion). Establish statistical reliability. Rate performance. Determine and apply allowances.</p> <p>Conduct methods study. Establish gross elements to be timed. Record time with stop watch or camera (memo-motion). Establish statistical reliability. Rate performance.</p> <p>Determine and apply allowances. NOTE: This type of work is frequently highly irregular before analysis, but is susceptible to a reasonable amount of standardization of method.</p>
2. Work Sampling	a. Irregular work where a work unit is highly correlated to work input.	Clerical, rebuild, repair, warehousing, facility maintenance, indirect labor.	<p>Prepare gross description of method. Define elements and end points. Choose level of accuracy desired.</p>

FIGURE 7-2

Techniques	Type of Operations	Examples of Operations	Application of Techniques
2. Work Sampling (Cont'd)			
b.	Development of management information. (NOTE: Not used to establish work measurement standards)	Determination of delays, utilization of people and equipment, work distribution, feasibility studies, performance checks.	Establish number of observations required for statistical reliability. Set up random schedule. Make instantaneous observations and tally. Obtain production count during study. Rate performance (random sampling) Determine and apply allowances.
3.	Predetermined Time	a. Repetitive short cycle work where volume is high.  b. Check as to consistency of direct time study standards.	Define elements and end points. Establish number of observations required. Set up random schedule. Make instantaneous observations and tally. Determine percentage of total time spent on various categories of work and non-work.  Standardize method (break-down into basic motions) (therbligs). Make precise measurement of all variables, such as distance. Determine time values from tables. Determine and apply allowances.  See as in 3a.

Techniques	Types of Operations	Examples of Operations	Application of Techniques
4. Standard Data	a. Repetitive work and medium cycle work where volume is high.	Assembly, machining, packaging, typing, filing, editing.	Determine and define motion patterns (elements). Average the variables into small categories. Determine time values from Pre-determined Time Standard Tables (in some instances from Direct Time Studies). Arrange in one of following forms for rapid and economical use: tables, curves, nomographs alignment charts, multivariable charts, formulae.
	b. Repetitive work where volume is low, or long irregular cycle work where work volume is high.	Assembly, machining, packaging, rebuild, repair maintenance, clerical, warehousing.	Determine and define motion patterns. Average the variables into gross categories. Determine time values from Direct Time Studies or Predetermined Time Standard Tables. Arrange as in 4a.
5. Technical Estimate	a. Highly technical or irregular work.	Maintenance, rebuild, repair of complex items.	Break down operation into elements. Estimate time it <u>should</u> take to perform work (est. made by supervisor, inspector, analyst). Use historical reports, standard data, time study, experience, etc. for each element.

Techniques	Types of Operations	Examples of Operations	Application of Techniques
5. Technical Estimate (Cont'd)			Record data and evaluate. Determine and apply allowances to estimate.
	b. Scheduling and controlling projects for priority, status, evaluation and costing.	Technical, engineering, and research projects.	Same as in 5a. except the estimate is made by supervisor or project chief.
6. Historical	a. Irregular work where a work unit may be determined.	Administrative, indirect labor, warehousing.	Develop and/or analyze records of man-hours expended and related output of units produced. Measure central tendency (mean, median, mode, quartile, regression, etc.). Select realistic work unit and correlate input to output.

FIGURE 7-2

other work sampling techniques call for the observer to record what kinds of tasks the workers are engaged in, ratio delay simply classifies the worker as working or not working.

b. It can be shown statistically that a relatively small number of observations, or samples, tends to follow the identical description pattern that would result from a very large number of observations, or from continuous observation. (An observation is merely the classification and recording of any one individual unit at a randomly selected instant of time). Thus, in a relatively short period of time, through the use of ratio delay, a Should-Cost team may reliably establish the level of activity for given groups of workers in the contractor's plant.

c. Several steps must be followed in making a ratio delay study. These steps, generally, are:

- (1) define the problem,
- (2) estimate percentage occurrence of elements,
- (3) establish desired precision rates,
- (4) determine number of observations required,
- (5) determine time limit on study,
- (6) establish observation times and sampling routes,
- (7) make observations and record data,
- (8) summarize data, and
- (9) compute level of activity.

d. The clearest way to explain the steps is through an

example. Example: There are 35 Quality Engineers in a plant. Casual observation seems to indicate that many of them are not working. Since this proposal is for the sixth production buy, it is possible that this many engineers are not really needed. A ratio delay study seems to be called for.

(1) Defining the problem. Determine and categorize the information that is sought. The observers to be used in the study must understand the categories and be able to distinguish one condition from another. In the example, the condition of working and not working must be clearly defined and understood.

(2) Estimate percentage occurrence of job categories. In a ratio delay study, two job conditions or categories are of concern, working and not working. Other work sampling studies usually seek information on more than 3 conditions. To estimate the percentage occurrence of a particular job condition, a preliminary study is needed. A one-day study is made, going through the shop 10 times at random intervals. Five people were observed on each trip, so 50 observations were made with the following results:

<u>Working</u>	<u>Not Working</u>
35	15

This preliminary study gives an estimate of the working time as approximately 35/50 or a 70% level of activity.

(3) Establish desired precision rate. It has become customary in ratio delay studies to establish 5% as the precision level. Greater accuracy may be obtained, but the number of observations required will increase greatly. The estimated work time, in

our example, is 70%. Enough observations should be taken to be sure of accuracy within +5% (+5% of 70% = +3.5% absolute error). We call 3.5% the precision interval.

(4) Determine the number of observations. The number of observations can be determined several ways. The available literature on work sampling, ratio delay, and work measurement discusses the application of mathematical formulae and the use of tables. The quickest way is the use of a nomograph (see Industrial Engineering Handbook, page 3-88). For the example, a straight edge is placed on "average percent of occurrence" (70%) and the precision interval" (+3.5%) and the sample size (number of observations - N) read as approximately 695--round to 700. Note, one man seen working or not working constitutes an observation.

(5) Determine time limit on study. In a Should-Cost study, there will be a limit in the time available to a ratio delay study. In planning the study, it may be necessary to utilize observers from all sub-teams. In this example, 700 observations must be made in 5 days and 10 men will be available to help. So 140 observations a day or 14 per man are necessary.

(6) Establishing observation time. The safest way to establish a purely random observation schedule is through the use of a random number table. The individuals that are to be observed must be randomized to insure a true random sample. The observations can in this example, be made from 0800 to 1700, excluding lunch hour,

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or for 480 minutes per day. In some cases, observations at less than 10 minute intervals may be difficult, though any convenient interval may be used. Thus, we have 48 ten-minute intervals. Number consecutively the 10-minute intervals starting at 0800, as 01, to 1650, as number 48. Using a table of random numbers, select 14 numbers in a column or row from 08 to 48. Our numbers might be 29, 17, 12, 13, 40, 33, 20, 38, 26, 13, 03, 17, 37, 13, 04, 07, 21. Arrange the numbers sequentially to determine observation times as shown in Figure 7-3.

Sequence	Observation Time	Man
03	0820	16
04	0830	07
07	0900	17
12	0950	30
13	1000	29
13	1000	25
13	1000	02
17	1040	14
17	1040	34
20	1110	03
21	1120	09
26	1300	20
29	1330	04
33	1410	10

FIGURE 7-3

One observation consists of observing one man at a random instant in time, working or not working, and there are 35 persons in this

example. The man or men to be observed at each observation time must be randomly selected. Each observer, desiring 14 random observations of the 35 persons, should select 14 random numbers (including repetitions) from 01 through 35 thus designating the individual to be observed. Numbers might be 16, 07, 17, 30, 29, 25, 02, 14, 34, 03, 09, 20, 04, 10. These numbers are placed in the schedule of observation times (See Figure 7-3). Each observer will have a different set of times and different individuals to observe. Note also, that at 1000, the observer must check three individuals. The selection of individuals to observe is known as the sampling route. In large studies, the route could be from machine to machine, or department by department.

(7) Making observations and recording the data. It is important to the ratio delay study that observations be made on an instantaneous basis. The observer should walk to a particular spot, neither quickening nor slackening his pace, make a mark on the observation sheet and depart. One good tool for recording data is a pre-printed 3 X 5 card. The card can be retained unobtrusively in a shirt pocket and the observation recorded inconspicuously. Some authors suggest that the observation be made and the observer step out of sight before writing the number down. Figure 7-4 shows a data card partially completed with the data from the example.

(8) Summarize data. The completed cards should be collected at the end of each day and summarized. Figure 7-5 shows an example of a Summary Sheet. The cards should be retained, since

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they will prove useful if there are irregularities in the summary sheet or if the work of one observer is questioned.

Observer <u>John Snord</u>				Date <u>6-9-70</u>			
Department <u>Quality Control Engineering</u>							
Time	Man	Work	Not Work	Time	Man	Work	Not Work
0820	16	1		1100	03		1
0830	07	1		1120	09	1	
0900	17	1		1300	20		1
0950	30		1	1330	04		1
1000	29	1		1410	10	1	
1000	25	1					
1000	02		1				
1040	14	1					
1040	34		1				

FIGURE 7-4

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## RATIO DEI AY SUMMARY SHEET

FIGURE 7-5

(9) Compute level of activity. The level of activity of the organization is calculated as follows:

$$L = \frac{W}{N+W}$$

L = level of activity

W = total observations of work

N = total observations of not work

From the sample summary sheets it can be seen that 280 observations have been taken in two day, 195 of which were work (W) and 85 not work (N). So the level of activity (L) is:

$$\begin{aligned} L &= \frac{195}{280} \times 100 \\ &= 70\% \end{aligned}$$

#### 4. Time Study

a. Time study is useful to the Should-Cost team. If trained time study technicians or engineers are available, this technique can be used to gain an insight into the accuracy and reliability of a contractor's standards. To authenticate the value of the contractor's work measurement effort, hence, the reliability of their work standards, the Should-Cost team should begin by looking at production records. Select on a random basis a sample of their work units which "earn" a lot of hours or the units which represent a large number of hours in the product cost. The team should review the standard and the back-up information and ask the following type questions.

(1) Where did each time value come from? All time values in the standard should have come directly from stop watch readings or MTM values. In some cases- time values can be transferred-- or extracted from other standards. In such cases there should be good cross reference on both standards to be sure that updating will affect both standards.

(2) Are cross-references given when other standards are used as a source of time values? Cross-reference should be shown on both the original standard and the built up standard to insure that periodic updating of time values will affect both standards.

(3) Was there any method improvement indicated? One of the main purposes of time and motion study is to develop standard methods. Though every standard may not include methods improvement, some of them should. It may be possible to obtain monetary value of methods improvement.

(4) Were the observations sufficient to gain some level of statistical accuracy? There are several methods of checking the statistical accuracy of time standards (see United States Army Management Engineering Training Agency, Work Measurement, 1967, page 6-15).

(5) Are the work measurement technicians trained in rating? There should be an active program to insure that individuals using stop-watch studies are up-to-date in performance rating or leveling. There are many kinds of leveling; all are somewhat imperfect. It should be possible to obtain scores on leveling training

sessions and determine if there is an earnest effort to obtain the best standard possible.

(6) How often are standards reviewed and updated? The length of time between updating standards is closely related to the savings to be made in methods improvements. Workers are quite capable of improving methods so much as to make a once accurate standard obsolete. The difference in time is, of course, an unnecessary expense.

(7) Are fatigue, rest and delay allowances excessive? Though these allowances are often management policy, 15% is accepted as normal. In some work conditions, close tedious work, poor environment, hazardous work, and work in areas of mental stress, larger allowances are acceptable.

(8) Are delays self-imposed on the part of the production process? Allowances for delay can be grouped into three categories of personal and rest, unavoidable delays, and special allowances. Personal and rest allowance is usually management policy. It may be necessary to check allowances by means of a work sampling study. Under any condition, the allowance placed on standards should be based on company policy, work sampling studies, and some other auditable methods. Knowledge of work measurement techniques will add greater depth to the answers and will ease the detection of error, misstatements, and wrong calculations.

b. Time study, or standards setting by any engineered method, is costly and time consuming. It usually takes 7-10 times as long to

set a reliable standard as the standard time to be measured. Therefore, unless there are inconsistencies detected by a more gross level investigation, time study should not be undertaken. In cases where there is some question as to the validity of the time values, the company should be approached to make new studies with Should-Cost engineers observing. If it is necessary for the team members to make time studies, all individuals to be studied should be informed and permission gained through the company. Where shop stewards will be involved, they should be notified through appropriate company procedures.

c. The techniques for making time studies, while mentioned herein, are more fully described in specific texts, specifically, H.B. Maynard, Industrial Engineering Handbook, Section III. Other references are listed in the bibliography of the Should-Cost Library.

d. It is possible in a Should-Cost study that the company has no real standards for much of its production labor. If this is the case, a selection of representative tasks or operations may be studied by one of the IE techniques to gain some insight into the target and budget. If trained time study personnel are available, a time study or work sampling may be used; technical estimating is the appropriate technique if trained personnel are unavailable.

##### 5. Technical Estimates.

a. The technical estimate is another IE approach which is particularly useful in evaluating the methods and processes used by

the contractor, and their effects upon labor utilization. This approach can also be used to evaluate standards when the possibility of performing time studies is denied to the team. It might be added that technical estimates sometimes must be used because there is so little actual work in the contractor's shop that it is not sufficiently representative of the proposed effort.

b. A technical estimate is made by determining all the factors that affect the worker as he performs the task; all the steps the work goes through, machine set-up time, and machine limitations. The factors are then listed in the sequence in which they occur, and time values are estimated and various allowances included. The technique is dependent to a large part on the experience of the analyst.

6. Clerical Short Interval Scheduling or Batch Control.

a. Short interval scheduling is a technique which was developed for the primary purpose of controlling very repetitive clerical operations. It should be specifically pointed out that this technique is not applicable to secretarial type positions in that their work is too diverse. This method of control has proven most effective in keypunching, filing, posting inventory cards, processing customer orders, and in processing purchase orders.

b. The theory behind this technique is quite simple. Prior to short interval scheduling, a worker's desk was filled with the backlog of documents requiring her attention. The clerk controlled her rate of work which was directed at reducing the backlog. When the individual approached completion of the backlog, she slowed down not

wanting to be without work to accomplish. Therefore, the worker was continuously busy at various rates depending primarily on the size and urgency of the backlog of work that was before her. Short interval scheduling attempts to give the supervisor control of the clerk's time and rate of work. Under this technique, the supervisor, not the worker, is concerned with the backlog of work. The supervisor gives the worker small "batches" of work; thus the term batch control is sometimes used. These batches of work will require a known amount of time for the clerk to process them. Thus, the supervisor assigns batches of work with an expected completion time and checks to see that the work is accomplished on time. The clerk is only concerned with completing the batch of work that she is presently working on and not the size of the backlog. When the backlog is completed, the worker should be utilized in other areas. It is through improved worker utilization that increased efficiencies are obtained.

c. In practice the development and implementation of a clerical short interval control system is not overly difficult. The requirements of the system are batch standards and reporting procedures. Batch standards are the times required to complete batches of work. A batch of work should normally be about an hour. The establishment of a standard involves the determination of how many documents or inches of documents that can be processed in an hour. Usually none of the engineered methods are used in this determination; however, they may be. The most frequent approach is trial and error. The supervisor should give the clerk a certain quantity of documents, observe the clerk

to see that she is working at a proper pace, and record the time necessary for completion. Then by changing the number or inches of documents the supervisor can determine adequate batch standards. These standards can be validated by the supervisor actually processing one batch.

d. The reporting procedure need only record the start and stop time for each batch. The lapse time is then compared to standard, and the supervisor takes whatever action is necessary depending on the deviation of the comparison.

e. Thus, in both theory and practice, short interval scheduling and control procedures have proven to be a simple and practical manner of increasing and maintaining clerical efficiencies.

### III. Management Science/Operations Research Techniques.

#### 1. General

a. It is acknowledged that one of the Should-Cost analyst's biggest constraints is time. It is discouraging to observe a problem solvable only by a technique one knows to take more time than is available. In this section the intention is to cover only those techniques that are feasible for use by the analyst. There are, however, many management science/operations research techniques appropriate to Should-Cost analysis that have a time (and immediate resource) limitation. For example, waiting lines situations are good "OR" type problems. When a bottleneck in production is found, such as trucks lined up or workers waiting on other workers, a

queueing model can be developed and perhaps even computer-simulated to find the optimum combination of machines, personnel, arrival time and other factors. The Should-Cost study limitations will not allow this type analysis.

b. When the analyst has found an area, highly researchable but beyond the time/resource capability of the local team, he should attempt to enlist outside help from either the sponsoring command, the Army Procurement Research Office, other Army agencies, or outside consultants. While the Should-Cost team is continuing its work, the outside help can concentrate on the special problem, develop a model, analyze the data and feed back results.

## 2. Inventory Control

a. Inventory control serves the attention of top management since for many firms the inventory figure is the largest item in their current asset group. Poor inventory control will contribute to higher costs, and in some extreme cases bring production to a halt. Hence, skillful inventory management can make a significant contribution to the reduction of a firm's costs. This section will identify and define some basic techniques and models used to measure the relevant inventory costs.

b. Management must concern itself with minimizing two major classes of costs: procurement costs and stockage costs. Procurement costs are basically the costs associated with getting an item into the firm's inventory. When outside suppliers are involved, the procurement

costs are referred to as ordering costs, but when the commodity is self-supplied, then as set-up costs. The stockage costs are the costs incurred by carrying and not carrying inventory.

c. Ordering costs include all cost components incurred in placing an order. They start with the time spent reviewing the goods to see how many must be ordered. Next they include all costs of issuing and keeping track of the purchase order; and continue with such steps as receiving the goods, placing them into the inventory and finally, paying for them. Salaries may constitute a major portion of the ordering costs, and stationery a minor one.

d. Set-up costs are associated with firms who make items on a job-order basis to be used on their own production line. The set-up costs then refer to the cost of changing over the production process, and the clerical costs involved in sending the order to the production department. If the firm has a continuous production line, then the set-up costs are those associated with varying the production level such as hiring, firing, training, etc.

e. Carrying costs, sometimes referred to as holding costs, are basically the costs incurred because a firm owns or maintains inventories. Carrying costs include the interest loss on money invested in inventory. This is a major cost, since the money tied up in inventory is not available and this fact requires that a cost be assigned to reflect lost earning power. There is usually a cost associated with the space required to store an item. This may or may

not be a major cost, depending on whether there is an alternative use for the space in question. If the storage area cannot be sold or rented and there is no alternative profitable use for the space within the company, then the space is a fixed cost which may be minor. Taxes, insurance, and depreciation are usually minor costs. Deterioration costs include actual deterioration, obsolescence, or even pilferage of items in the inventory. This might be a major cost. Stores operation, including record keeping, taking of physical inventory, and the protection of the inventory by burglar alarms, fire alarms, or watchmen are included in carrying costs. There is also a cost which occurs when the demand for an item has terminated and the item is still in the inventory. This cost is called the overstock cost. Annual holding costs are often referred to in industry as a percentage of the product unit cost. When the contractor does not have any information about his actual holding costs, a frequent approximation is twenty percent of unit cost.

f. The cost of not carrying inventory is called out-of-stock cost. The effect of this cost may range from the necessity of substituting an inferior or more expensive item for the out-of-stock item to the interruption of some production process because of the lack of some crucial raw material. The out-of-stock cost possibilities should be especially investigated in the Should-Cost studies.

g. To minimize total inventory costs, management must then minimize procurement costs and stockage costs simultaneously. This is done by solving for an economic order quantity which will keep total

annual inventory cost at a minimum.

h. Figure 7-6 describes the procurement, stockage and total inventory costs along with the economic order quantity.

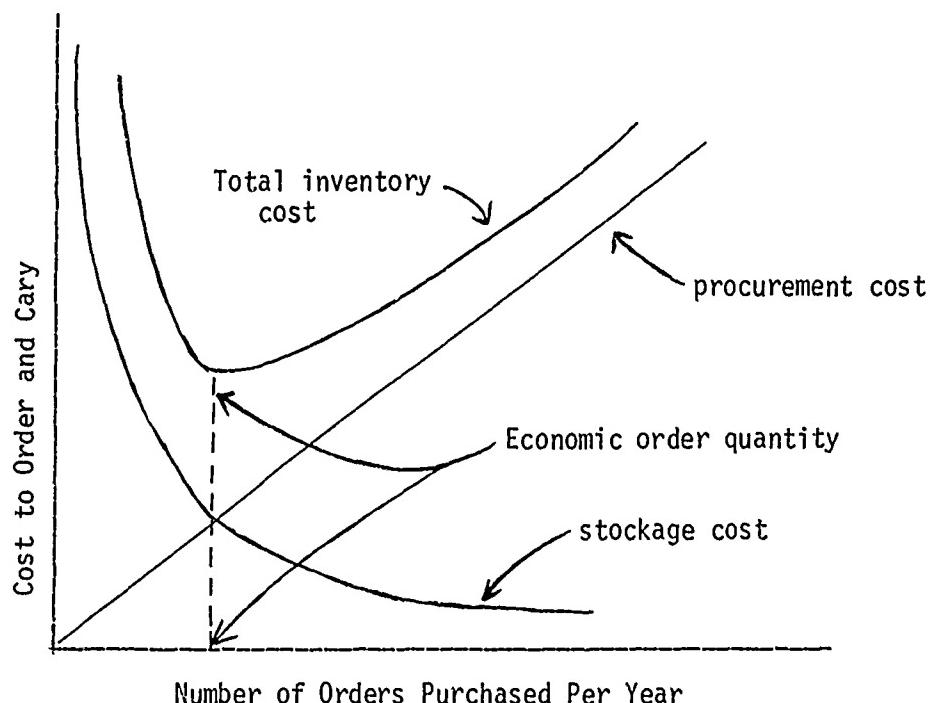


FIGURE 7-6

i. After an inventory item has been selected for investigation, the following information is needed:

$D$  = annual demand for the item

$M$  = annual manufacturing rate for the organization producing the item

$O$  = order cost or set-up cost to procure the item

$H$  = holding (carrying) cost for keeping each item in storage one year

$i$  = interest rate for money invested in inventory stock

$P$  = price of the item

$Q$  = number of items procured for each inventory replenishment

$Q = D$  when all the items needed for an entire year are procured at one time. When inventory is replenished more than once a year,  $Q = \frac{D}{N}$ , where  $N$  is the number of procurement periods per year. Immediately after a procurement is made there are  $Q$  units in storage. If a constant usage rate is assumed along with the assumption that all the items in storage are depleted before another procurement is received, the average inventory stored is  $Q/2$ . Then the total annual holding cost is  $HQ/2$ , the interest charge is  $\frac{iPQ}{2}$ , which makes the total carrying cost to be  $(H+iP)\frac{Q}{2}$ .

j. The costs of placing an order or preparing to produce an order,  $O$ , occur once each procurement period. The total annual preparation cost is the order cost for each procurement period,  $O$ , times the number of periods per year,  $N$ , hence the procurement cost is  $\frac{OD}{Q}$ .

k. Assume that the price of an item remains unchanged throughout the year, then the total annual purchase cost is  $DP$ .

1. The total inventory cost is the sum of the above costs, hence, the equation needed is:

$$C = \frac{OD}{Q} + \frac{(H+iP)Q}{2} + DP$$

The terms in the above equation may be changed to fit specific inventory patterns, but the main objective is always the same--to minimize C by obtaining the optimal quantity Q. That value of Q which minimizes C is referred to as the economic order quantity (EOQ) or economic production quantity (EPQ).

In obtaining Q certain assumptions are made which indicate an inventory pattern as shown in Figure 7-7. The assumption made to arrive at this graph are that the rate of usage or demand is constant and that the time interval between ordering goods and receiving those goods (known as lead time) is constant. With these assumptions, the minimum cost equation is used to solve for the economic order quantity as

$$Q = \sqrt{\frac{\text{inversely varying costs}}{\text{directly varying costs}}}$$

$$Q = \sqrt{\frac{2 CD}{H+iP}}$$

If the interest charge is included as part of the total holding cost, as is usually the case, the order size formula becomes

$$Q = \sqrt{\frac{2 OD}{H}}$$

Hence our equation may now be written as

$$\text{total annual cost} = \sqrt{2 O DH + (DP)}$$

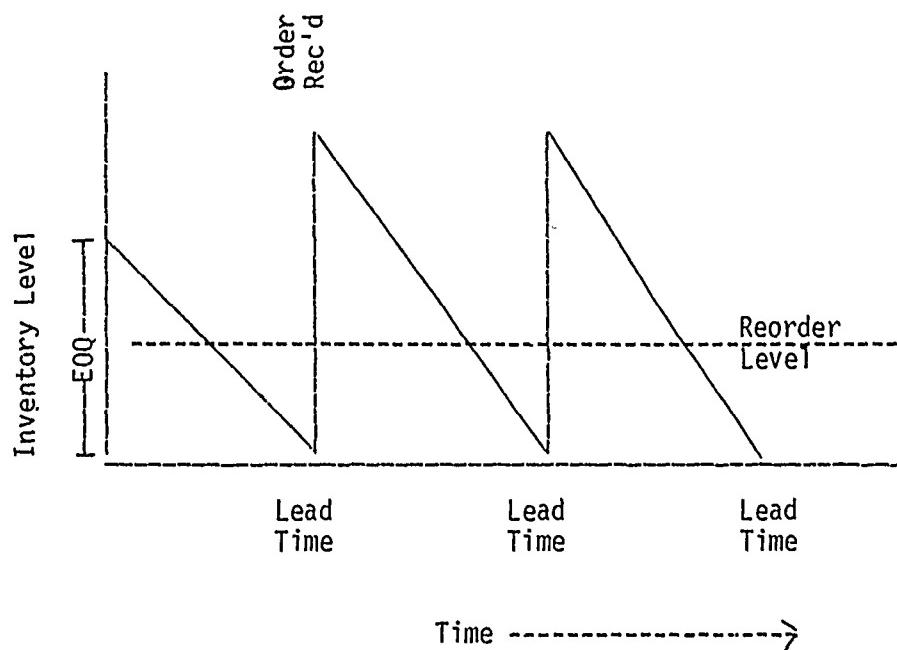


FIGURE 7-7

n. These assumptions may not always be realistic since planned usage of an item may be thrown off by a strike, power failure, accidents, sudden increases in demand. Likewise the lead time between ordering required material and obtaining delivery often varies since the supplier may run into similar difficulties. Stockout will occur when demand is normal but delivery is late, and when the

delivery is on schedule but usage is greater than expected.

Management's desire to avoid stockouts leads to further considerations of when to order or reorder. The reorder point is what tells the purchasing agent that it is time to replenish the inventory. Reorder points reflect the rate of use and lead time. To determine the reorder point, multiply usage (number of units used per day) by the lead time (in days).

o. If a stock out is extremely critical and costly to the production of an item, extra inventory is held as protection against the possibility of a stockout. This extra inventory is known as safety stock. Obviously the safety stock will decrease the costs of stockouts but it will increase the firm's carrying costs. The cost of a stockout multiplied by the number of stockouts prevented by the safety stock gives the cost reduction figure. The value of the safety stock multiplied by the carrying cost percentage gives the cost addition figure. Note that this cost addition will continue since it is always part of the total inventory. Because the safety stock does not often decline in quantity it is not divided by two to get average inventory. To compute the reorder-point when safety stock is on hand, multiply the average daily usage by lead time in days and then add the safety stock.

p. In buying inventory a manufacturer may obtain a discount on his goods if he buys a certain large number. The following are some advantages gained by buying big: lower unit prices, cheaper transportation, lower ordering costs and fewer stockouts. But

quantity buying can involve the following disadvantages: higher carrying costs, lower stock turnover, obsolescence, heavier deterioration and depreciation, and more capital tie-up. Probably the simplest cost comparison approach, is to compare the total cost of ordering and carrying under conditions which qualify the manufacturer for the quantity that is most economical at the discount rate. The optimal quantity is then that number where the reduction in ordering cost and in unit price is equal to the additional carrying costs which result from buying in larger amounts.

q. Recall that procurement costs are broken into two categories, ordering costs and set-up costs; and that set-up costs are associated with firms who make items to be used on their own assembly lines. The economic production quantity, EPQ, is associated with this environment rather than the EOQ. The difference between the two quantities is due to the delivery time. EOQ calculations are based on an assumption of instantaneous delivery time. EPQ calculations deal with the gradual build-up of inventory over a period of time as it comes off the production line. The assumptions are that demand rate is constant; production rate is constant and equal to or greater than the usage rate; ordering costs include the cost of setting up production lines and procuring material for the production run; and unit costs are constant. If the manufacturing rate M is equal to the usage rate D, then the items will be used as fast as they are produced; but if M is greater, then the inventory is accumulated at the daily rate of  $(M-D)/days$  per year. The inventory level reaches a maximum after  $Q/M$  days, where M is the daily production rate. This

level is equal to  $(M-D) Q/M$ , and the average inventory is half this amount, or  $(Q/2M)(M-D)$ . Therefore the total cost is

$$C = \frac{OD}{Q} + \frac{HQ}{2M} (M-D) + DP$$

and the economic production is

$$Q = \frac{20D}{H(1-P/M)}$$

In this case, it should be noted again that  $O$  includes set-up costs and the costs of procuring required materials. Figure 7-8 explains the economic production quantity situation.

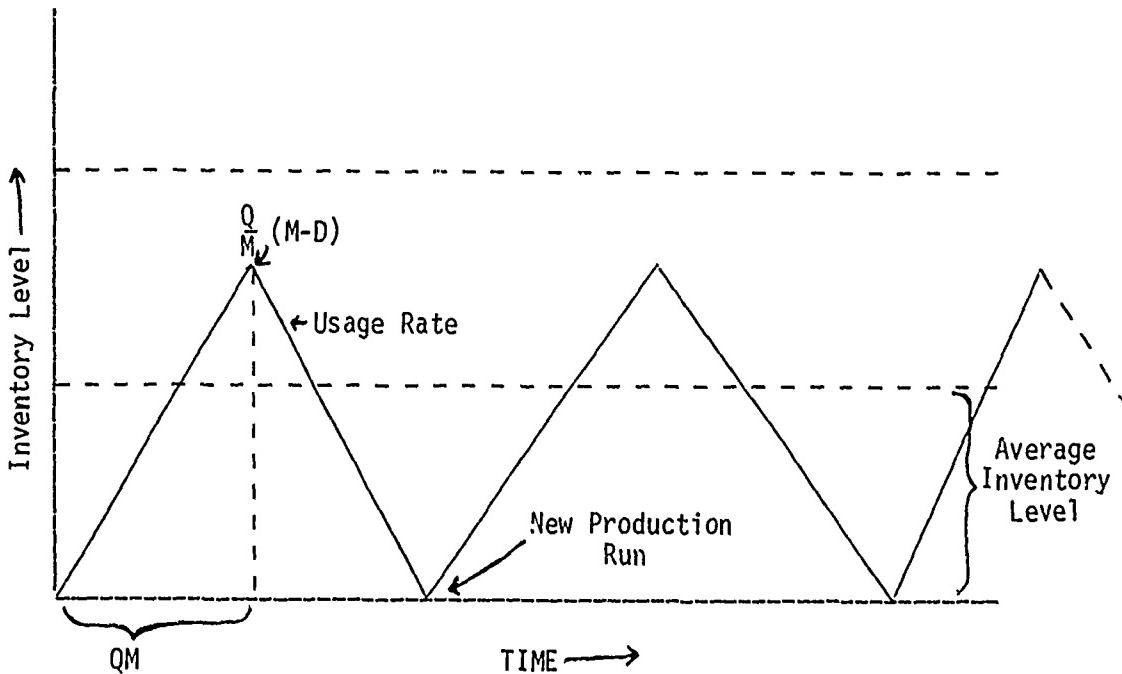
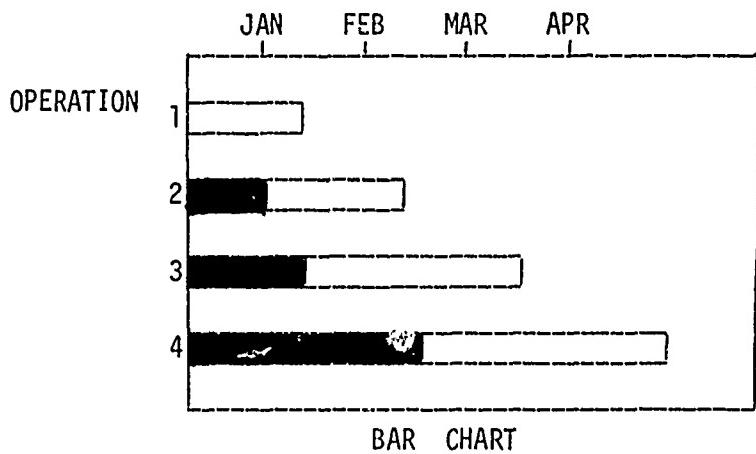


FIGURE 7-8

### 3. Production Planning and Control

a. It is imperative that the contractor use some accepted method of planning, scheduling, and controlling his operations.

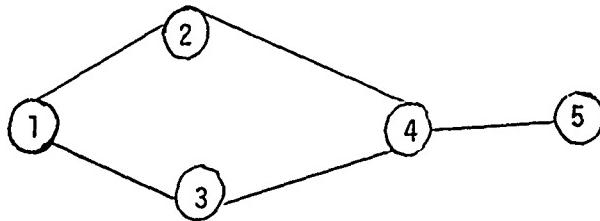
Traditionally the most widely used technique has been the Gantt, or bar chart. This chart lists the operation elements down the side and units of time across the top.



It is a straight forward representation of activity but can be made more sophisticated by use of "earliest" starting and completion times in figuring a critical path schedule, by use of various "shading" methods of the time bars to indicate progress, and by other additions to the chart. While it has the advantages of flexibility and relative simplicity, it is often criticized for being a linear and static view of task progression.

b. In order to get a more dynamic picture (and for other reasons) management has devised network analysis in the form of events,

activities, and constraints. In this way the sequential plan can be seen.



SIMPLE NETWORK

c. A number of techniques have been developed to analyze a network of activity. The most widely used are PERT (Program Evaluation Review Technique), CPM (Critical Path Method), and PERT-COST. PERT (often called PERT/Time) is a technique in which an optimistic time, a pessimistic time, and a most likely time for each activity are estimated. These estimates are used to find an expected time for each activity in the following manner:

$$t_e = \frac{t_o + 4t_{ml} + t_p}{6}$$

$t_e$  = expected activity time

$t_o$  = optimistic time

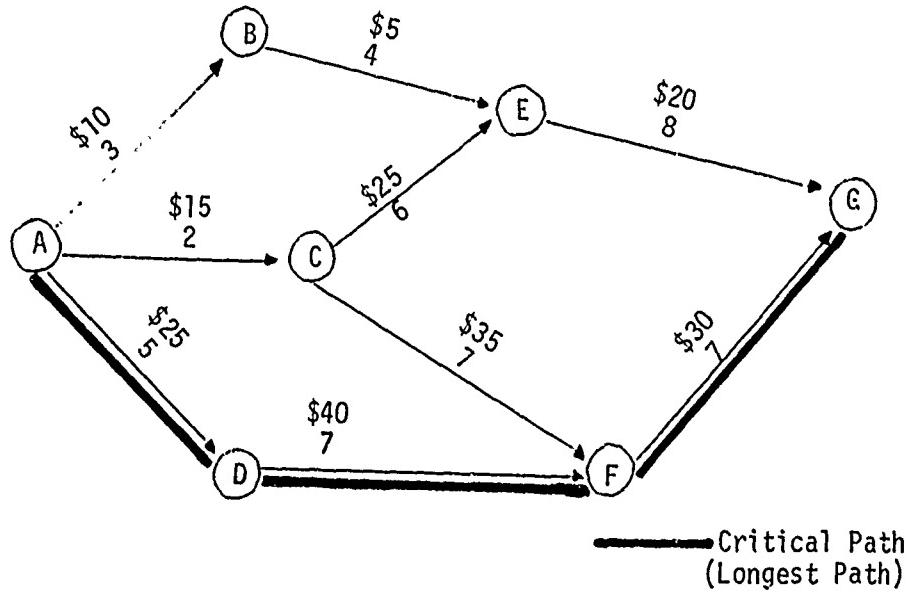
$t_{ml}$  = most likely time

$t_p$  = pessimistic time

and the standard deviation,  $\sigma$ , is estimated by:  $\sigma = \frac{t_p - t_o}{6}$

d. That sequence of activities and events which is longest is called the critical path and is found by summing the activities of the various paths. The "slack" of each activity is found by subtracting the time of the activity from the Critical Path Time. These calculations are, of course, important from the standpoint of planning and control.

e. PERT/Time is ideal for controlling the time element of a project but is of little use in handling cost and utility. These factors are introduced in PERT/COST. The cost of each operation is estimated for normal activity and the marginal cost of each operation for "crash" activitiy can also be introduced. In this way different alternatives can be viewed in terms of both cost and time.



f. Now one can evaluate overall time and cost progress and pinpoint overruns and slippages. This chart serves as a mutual talking vehicle between the government and the contractor.

g. The use of linear programming as a scheduling aid is becoming more accepted by industry. However, the use of this technique requires a degree of sophistication that can not presently be demanded of all contractors. Thus, although efficiencies will frequently result through the use of management science technology, consideration must be given to the objective of Should-Cost--reasonable efficiencies.

#### 4. Management Control

a. The law of span of control is one of management's oldest. Only so many men can be controlled effectively by one manager. For a number of reasons defense contractors may tend to violate this basic tenet. Span of control is, of course, a function of many things--complexity, number of operations, and level of supervision among others. There are general standards established for different types of work, and these should be used to assess the contractor's span of control as previously mentioned.

b. Once the span of control is established, the next area of investigation is the number of levels of supervision the contractor has. Although there are no management absolutes and the area is mostly subjective, one formula commonly used<sup>1</sup> for determining the number of levels that an organization should have is the following:

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<sup>1</sup>Moore, Franklin G., Manufacturing Management, 4th Ed., Richard D. Irwin Inc., Homewood, Ill. 1965, pp 27-28.

$$L = \frac{\log P - \log S}{\log R} + 1$$

where       $P$  = number of primary operatives

$S$  = span of control for foremen

$R$  = span of control above the foremen level

$L$  = number of levels of supervision

Example: Find the number of levels needed in a plant of 10,000 workers, with a span of control of 20 for foremen, and 5 for all higher executives (the span of control figures are derived from industrial standards).

$$L = \frac{\log 10,000 - \log 20}{\log 5} + 1$$

$$= \frac{4.0 - 1.301}{.699} + 1$$

$$= 4.9 \text{ or } 5 \text{ levels}$$

c. Lastly, contractors are often overstaffed with executives and this may prove to be an area for potential savings. In line with the formula above, also:

$$E = \frac{P(1 + 1/R + 1/R^2 + 1/R^3 + \dots 1/R^{L-1})}{S}$$

$E$  = number of executives

In the example

$$E = \frac{10,000 (1 + 1/5 + 1/5^2 + 1/5^3 + 1/5^4)}{20}$$

$$= 625 \text{ executives}$$

5. This Management Science/Operation Research Techniques Section has by design been limited to only a few of the available techniques that are fairly easy to apply. Others can be found in the Should-Cost Reference Library. The applicability of any technique will depend on the particular situation with time being the major constraint. Therefore, a Should-Cost effort in this area should only be undertaken after the advice or consent of a sub-team chief.

CHAPTER 8  
CONCLUDING THE SHOULD-COST EFFORT

I. General

This chapter covers the three final phases of the team's effort: the Should-Cost report, the Management Improvement Program, and the negotiation of the contract.

II. The Should-Cost Report

1. The report is the cumulation of the team's analytical effort; as such, it serves four significant purposes:

a. It will become the principal negotiating tool for the Government.

b. It will be useful for follow-up and surveillance by the cognizant audit and contract administration agencies.

c. It will be helpful in communicating "lessons learned" to future teams.

d. It may be required to help support the Government's position in legal or administrative actions.

2. The report writing phase of the team's work has proven itself to be one of the most difficult and exasperating tasks associated with Should-Cost analyses. The problems are rooted in three principal causes:

- a. There are inherent difficulties in interdisciplinary communications among such specialists as engineers, auditors, and contracting people.
  - b. There is a genuine shortage of people who are skilled in writing effectively.
  - c. The urgency of the analytical effort often prevents team members from gaining a real appreciation of the reporting task until they actually start writing.
3. The problems described above will always exist to some degree. Their impact on the quality and timeliness of the report may be minimized considerably by selecting team members with broad backgrounds and proven writing ability (as discussed in Chapter 3). Another important action, already mentioned in Chapter 5, is that the team's orientation should describe the nature and format of the report; the members should be thoroughly instructed so that they will be "thinking" the report as they perform their analyses. This will enable the members to prepare a modestly detailed overall outline of their elements for the team and subteam chiefs' review before actually starting to write the final report, and will help to insure that all key points are covered and in logical sequence.
4. The following points will help to reduce the report writing problems:

- a. Be certain that each writer and typist understands and follows the report format.
  - b. Have ready access to a copying machine. The ability to reproduce data is a significant time saver.
  - c. Maintain a "status board" for tracking each section of the report as it is drafted, typed, and put through the various stages of review and editing.
  - d. Designate one individual to control typing priorities.
  - e. Do not waste time proofreading the initial drafts. These drafts should be read for content and organization only.
  - f. Establish a "review board" to review each draft of the report. The board will also assist the proofreader in the final draft.
5. Should-Cost reports should usually be broken down as follows:
- a. Section I. Introduction
  - b. Section II. The detailed evaluation plans used for the study.
  - c. Section III. Summary report containing the negotiation position and alternatives and other general findings and recommendations, with cross-references to the detailed data in Attachment 1 and the contractor's proposal.
  - d. Section IV. Lessons Learned

- e. Attachment 1. Detailed report which relates the analytical work done and is the substantiation of the negotiation position.
- f. Attachment 2. Price Negotiation Memorandum.

While the writing of the report should precede negotiations, it is recognized that the finalization of Attachment 2 is dependent upon the completion of negotiations. Also, because of its scope and content, Attachment 1 may not be ready for printing concurrently with Sections I through IV. Additionally, the distribution requirements may differ. For these reasons, Sections I through IV, Attachment 1 and Attachment 2 are best published as three separate documents.

6. The following format and outline is suggested for the Should-Cost report:

- a. Section I - Introduction
  - (1) Background of the study; a brief summary of the contractor's business and its relation to the Government as a customer; how much of the contractor's past business has been with the Government, etc.
  - (2) Chronology of significant events, enabling documents, notification of contractor, study schedule span, proposed contract award date, etc.
  - (3) Study Summary
    - (a) Summary of pertinent RFQ requirements
    - (b) Contractual status, if applicable
    - (c) Brief description of proposal, quantities, prices
    - (d) Brief description of the major approach made to analyze the costs.

(4) Team Organization

b. Section II - Plan

(1) General

(a) Organization of plans

(b) Use of plans

(c) Master Milestone Schedule

(2) Detailed Plan

(a) General description of how the plans were developed

(b) Copies of the detailed planning sheets

(c) Copy of the master manloading chart showing resource allocations for each area of analysis.

c. Section III - Summary Report

(1) Summary of Findings

(a) Organized in same way as contractor's proposal

(b) Shows proposed, "Should-Cost" figures and difference for each item and for each basic element of cost

(c) This section may require two or three levels of summation if there are many items or if more than one fiscal period is involved.

(d) Each figure representing the difference between the proposal and the Should-Cost position should have specific reference to the segment of Attachment 1 that explains it.

(2) Findings and Recommendations

(a) Where the analysis has revealed basic system problems or irregularities in the contractor's internal operations, the recommended remedies should be stated.

(b) Where it is to the benefit of the Government to have the contractor make changes resulting from the Should-Cost diagnosis, the problems and recommended solutions should be clearly stated and made part of the negotiation provisions.

(c) Format should be in terms of

- i. Findings
- ii. Summary of supporting evidence
- iii. Quantity or quality aspects of the situation
- iv. Impact
- v. Recommended solution or approach

(3) Negotiation Position and Alternatives

(a) The detailed cost comparisons shown in the "summary of findings" section will be the negotiation objective.

(b) If alternative positions are recommended, they should be supported with the logic or rationale on which they are based and stated in ways that show exactly how they differ from the negotiation objective.

(c) Since alternatives will be part of the negotiation plan, the team chief (who will also be the negotiator) should decide to what extent, and in what manner, alternatives are to be discussed in the Should Cost report.

d. Section IV - Lessons Learned

- (1) Team Selection
- (2) Team Organization
- (3) Training or Other Preparation of Team Members
- (4) Planning and Scheduling
- (5) Procedures and Methodology
- (6) Report Preparation
- (7) Structure of Negotiation Positions
- (8) Other

e. Attachment 1 - Detailed Report

It is unlikely that any two contractors will prepare their proposals in exactly the same way. Therefore, because the organization must follow the proposal analyzed in a specific situation, there can be no exact guidelines. The sections cited below are typical examples and would generally be included:

- (1) General
  - (a) Describes organization of the sections of the detailed report.
  - (b) Tells how to read the sections, defines nomenclature of the contract items/services.
  - (c) Tells how to relate back-up data in Attachment 1 to summary data in Section III.

(2) Factory Labor

Generally separated into individual parts, one each for fabrication, assembly and test and evaluation.

(3) Quality Control Labor

(4) Material Handling Labor

(5) Tool Fabrication or Tool Make Labor

(6) Production Engineering Labor

(7) Model Shop or Experimental Fabrication Labor

(8) Engineering Labor

As with factory labor this generally is separated into subparts, such as System Design, Product Design, Drafting, R&D Labs, Field Support and Engineering Design.

(9) Factory Overhead

(10) Material Overhead

(11) Engineering Overhead

(12) Direct Materials

(13) Subcontracts

(14) Pooled Materials

(15) Other Direct Costs

(16) Inter-Divisional Cost Transfers

(17) Tooling Material

(18) Tooling and Equipment Maintenance

(19) Outside Processing Expense

(20) Field Support Labor

(21) Packaging

(22) Overtime Premium

(23) General and Administrative

(24) Independent Research and Development

(25) Bidding and Proposal

(26) Profit or Fee, including incentive arrangements,

Weighted Guideline Analysis, etc.

(27) The above list of detail findings and others that may be appropriate should be structured in the following manner:

(a) Purpose

(b) Personnel Involved

(c) Background Discussion

(d) Scope and Methodology

(e) Findings

(f) Conclusions and Recommendations

Structuring the detail data of the cost elements in this way will provide the logical support required for the Should-Cost position. Each recommended reduction will be validated by the underlying operation or system inefficiencies that lead to the reduction.

f. Attachment 2 - Price Negotiation Memorandum

7. In order for the report to be useful as a negotiating tool, its coverage must be easily related to the contractor's proposal. The following considerations should be helpful in establishing and maintaining this relationship:

a. Section III, the Summary Report, is a precis of the analysis in detail. It highlights the major findings and the logic behind the team's negotiating position. The report must allow the negotiators to readily relate and differentiate between the team's position and the contractor's proposal, in order to facilitate negotiation on a point-by-point basis.

b. To make certain there is direct comparison between the report and the contractor's proposal, the cost build-up sequence used by the contractor should also be used by the team in its report. That is, each line item and cost element used by the contractor in quoting the proposed cost must have a corresponding Should-Cost "line". If the contractor quotes on 25 contract line items and then applies the same elements of cost, the Should-Cost report will have the same 25-line matrix. This does not imply that the contractor's approach is the preferred way of organizing and presenting the data nor is it the

Should-Cost position must correspond on a one-to-one basis with the contractor's cost details, in order to facilitate discussion and understanding.

8. The content of each part may vary somewhat to suit the team chief's preferences. A well organized, concise, standard outline form is most effective and should be used. One of the tasks of the team's operations officer will be to construct a master outline for the entire report, providing specific and detailed formats for all parts of the report. Copies of the master outline should be provided for every member of the team and discussed in an explanatory briefing. (A sample outline is contained in the Should-Cost Reference Library.) The cost/item listing with Section III and Attachment 1 are governed by the organization of the contractor's proposal. The proposal determines the breakdown.

9. Depth of Detail of Various Portions of the Report

a. The depth of detail in each part of the report should be determined by the circumstances, the anticipated use, and expected "readership." Sections I, II and III are intended for a wide range of readers, particularly in higher headquarters. Section IV is the vehicle for the team to pass on insight and experience to future teams. Attachment 1 is a reference volume for use by negotiators at the table. The only part, then, where great depth of detail is required is in Attachment 1.

b. The parts of Attachment 1 must be in sufficient detail that the recommended costs can be traced back to specific contractor

data or conditions. There must be a clear and logical "audit trail" to basic data. The "trail" must be complete and comprehensive. Omitting relevant data will weaken an argument just as much as faulty logic. The sources of data must be cited, and included. The material must be expressed in such a way that any objective reader can follow the logical process and, using the same data, reach the same conclusion.

10. Charts, graphs, and illustrations may be used.

a. Graphics are convenient, and when properly used can be of considerable value to the reader. Charts, graphs, tables, diagrams, schematics, network displays and other graphic techniques should be employed in the report when they: (1) present a clearer form of expression; (2) convey more information in an easier to understand form; and (3) enhance the points being made in the narrative.

b. Despite the utility of graphics, do not force data into a table or chart when it does not lend itself to the application.

c. If charts are used, remember in the narrative: "Refer to the chart, don't repeat it."

III. Management Improvement Programs (also known as Goal Achievement Programs)

This section of the Guide is intended to provide only an introduction to the subject of Management Improvement Programs (MIP's). For more detailed information, see "Contractor Management Improvement Programs," a study contained in the Should-Cost Reference Library, and available to Should-Cost team chiefs, task coordinators, and training

personnel from the U.S. Army Procurement Research Office.

1. As stated in Chapter 1, one of the principal objectives of performing Should-Cost analyses is to bring about long-range improvements in the efficiency and economy of contractor's operations.

2. In and of itself, a Should-Cost pricing arrangement should induce a contractor to strive for improved efficiency. Indeed, a Should-Cost analysis is predicated principally upon the assumption that the contractor will act to attain recommended improvements because of the "pressure" of performing the contract at a more realistic price. If, however, the negotiation is directed entirely toward agreement on the instant contract's price, then the team's findings and recommendations concerning longer range improvements may receive little attention.

3. Under competitive market conditions, a prudent contractor will be highly motivated to make management improvements. In the absence of a true competitive environment, a Should-Cost analysis attempts to determine a realistic price. If the type contract to be negotiated is of a fixed-price nature, the profit incentive is expected to motivate the contractor sufficiently for accepting management improvements. Therefore, if the Should-Cost team develops recommendations for management improvements that can be implemented during the performance of the instant contract, and if their implementation will benefit the contractor, then he may normally be expected to adopt them. In such a case, the negotiator need not be concerned about having the contractor accept a

separate agreement on such improvements since his motivation should already be secured through the realistic fixed price and his desire to earn a profit.

4. There are, however, conditions above and beyond the impact of the instant contract price that may require specific agreement on needed improvements. Some of the conditions that may be expected to require a Management Improvement Program (MIP) are:

a. The use of a cost reimbursement or incentive-type instant contract, and/or the predominance of such contracts in the contractor's operations.

b. The existence of needed improvements which cannot reasonably be achieved in time to significantly lower the costs of the instant contract, but, if implemented effectively, will materially benefit anticipated follow-on procurements and/or other programs.

c. The existence of needed improvements which, for whatever reason, will not materially benefit the instant contract, but may be of significant benefit to other effort being performed concurrently. This case is obviously of special importance when the concurrent work is under cost reimbursement and/or incentive contracts.

5. The need for a Management Improvement Program, and its general information and content, should become apparent during the Should-Cost analysis. The team should be watchful for circumstances, such as those described above, that might warrant the requirement for improvements above and beyond the instant contract.

6. If it is determined that a MIP is required, it is most important that its negotiation not be separated from the overall negotiation of the contract price. This is not to say that the MIP need be negotiated as part of the contract, per se, for it may be a completely separate agreement (this point is discussed later in this section). The point to be borne in mind is this: the MIP issues must be resolved prior to, or along with, the price negotiation, and would be severely handicapped at any later stage due to the loss in the Government's bargaining power after price is settled. Since a contractor's chief motivation in negotiation is to reach agreement on price and associated matters, it follows that the contractor would have little motivation to enter into meaningful MIP negotiations after the price is finally established.

7. Although it would be possible, and in some cases desirable, to limit a "Management Improvement Program Clause" to the instant contract, there are compelling reasons why the program should apply to performance beyond the instant contract. Some of these reasons are:

a. If implemented only as a clause in the instant contract, the MIP would not generally be held applicable to other contracts, would expire upon completion of the instant contract, and would therefore not achieve the long-range improvements for which it was developed.

b. If implemented only as a clause in the instant contract, the MIP would then become "just another" special provision of many

provisions among many contracts, and might very well lose the impetus of attention needed to accomplish its objectives.

c. If implemented only as a clause in the instant contract, its achievement is not likely to attract the same level of interest and "policing" that would be gained by establishing the agreement at a higher level than normally encountered in contract signatories.

8. It must be recognized that the contractor's undertaking of management improvements will cost money. Additionally, the savings that occur, especially beyond the instant contract, will accrue to the Government, principally, and not to the contractor. (The contractor may, however, derive other benefits, such as an improved competitive position attributable to improved cost efficiency.) Generally speaking, the contractor will recoup the costs incurred in implementing the MIP through overhead allocations--but mere recouping of cost is of little motivation to undertake some of the more difficult remedies that may be called for. Beyond cost recoupment, then, what factors will motivate the contractor to strive to achieve the desired management improvements? There appear to be a number of potential forces to motivate him to implement Should-Cost management improvement recommendations:

- a. The contractor's expected desire to improve his efficiency, and thereby his competitive position.
- b. The impact upon profits and losses.

c. The possibility that his response to the recommended improvements may become a factor in future source-selection evaluations.

d. The impact on present and future profit negotiations (the Government should have more confidence in the contractor's cost estimates and be more liberal with its weighted guideline profit consideration in recognition of his management improvement efforts).

e. The impact of demonstrated management improvements on the selection of contractors for future Should-Cost analyses. A contractor who has undertaken an aggressive and successful Management Improvement Program in response to a Should-Cost analysis would appear to be reasonably "exempt" from another analysis, at least while the Management Improvement Program is in progress.

9. In addition to the above motivating forces, consideration may be given to the following specific contractual methods:

a. Award Fee Provisions: ASPR 3-405.5(h) now permits the use of award fees in other than cost-plus-award-fee (CPAF) contracts and under circumstances that might be expected to exist where an MIP is contemplated. Although the MIP, itself, might be contained in a separate memorandum of agreement, it would be incorporated by reference in the instant contract and the award fee provision would also be covered therein.

b. Special Profit Incentive Provision: Another approach that

may be found practicable is the use of a special profit incentive in the instant contract, stating specific amounts of additional profit that the contractor could earn as he attained specific levels of achievement in implementing elements of the MIP. For example, attaining a specified level of labor efficiency by a certain time might earn "x" dollars, and the amounts of additional profit could increase, within stated parameters, as the rate of improvement was accelerated. Obviously, the special profit would similarly decrease if the rate of improvement did not make "par." Such an arrangement would require careful structuring, with detailed ground-rules for computing the levels of achievement. Nevertheless, there are many areas of management that are subject to highly objective evaluation, where the results are clearly tangible, and the benefits are easily quantifiable. It is only in these areas that this approach appears appropriate.

c. Combinations: There may be instances in which combinations of the above methods may be appropriate. Such a case might exist where award fees could be paid for achieving certain comparatively intangible improvements, while special profit incentives could be paid for achieving other improvements whose benefits are easily quantified. Therefore, in addition to the weighted guidelines profit consideration already mentioned, both the award fee and/or special profit incentive provisions can be used to encourage the contractor to accept and pursue a Should-Cost Management Improvement Program.

10. In order to insure that both parties fully understand the improvement to be sought, reporting requirements, and other aspects, it is important that a specific, point-by-point agreement be reached. Then, a formal Memorandum of Agreement describing the program should be developed. The agreement should be between the two respective highest level executives involved in the transaction, such as the military HPA and the contractor's executive vice-president or plant manager. Even though the document would, of itself, be non-contractual, it should clearly state the intent of the parties to incorporate its provisions, by reference, into all major contracts negotiated during the agreement's existence. The agreement thereby gains its strength through the interest and obligation inherent in the levels of the signatories, through contractual incorporation by reference, and possibly by the use of financial incentives in one or more contracts as already discussed. The agreement should clearly cover a plant-wide "cost-conscious" management improvement program involving contracts performed concurrently and in the future--in addition to the instant contract. An example of a Memorandum of Agreement is shown in Figure 1.

11. The following steps will be necessary to formulate, implement, and administer a Management Improvement Program.

a. The Should-Cost analysis would identify those areas of the contractor's operation requiring long and short range management improvements.

FIGURE 8-1

**MEMORANDUM OF AGREEMENT**

between

## XYZ Company and the United States Army

## Subject: Management Improvement Program

1. The parties to this agreement recognize and affirm that it is to their mutual advantage to seek maximum efficiency and economy of operation in the performance of their contracts. In order to assist the parties in defining and attaining specific objectives of efficient performance, we have reviewed the operations essential to the performance of our mutual contracts, and have identified certain management improvements to be sought. These improvements are covered by this agreement, and are specified in the attachments.

2. XYZ Company agrees to take the actions indicated in the attachments to this agreement, and make every prudent effort to accomplish the improvements described therin.

3. XYZ Company also agrees that any reports that may be required monthly, by contract, on progress toward accomplishing the improvements will be closely analyzed by the Executive Vice-President, XYZ Company.

4. XYZ Company agrees to provide such additional information as the Army may reasonably require, concerning the status and progress of this Management Improvement Program.

5. The parties agree that this Memorandum of Agreement shall be incorporated into all contracts negotiated between the parties, until all of the improvements are accomplished or until the agreement is terminated by mutual consent.

(Date) (Date)

for XYZ Company for the US Army,  
Executive Vice-President Commanding General (Command)

## Attachments:

- #1: Labor Standards and Realization
  - #2: Cost Estimating System
  - #3: Make or Buy Practices
  - #4: Indirect Engineering Personnel Levels
  - #5: Use of Small Business Subcontracting
  - #6: Materials Control and Cost Accounting System

- b. Normally, short range improvements would be negotiated into the instant contract price, while long range improvements would be negotiated, as a Memorandum of Agreement with award fee and/or special profit provision considered for incorporation into the instant contract and not treated as a separate, subsequent negotiation.
- c. Document the extra-contractual understanding as a Memorandum of Agreement, signed at the highest levels.
- d. Incorporate the MIP, by reference, into the instant contract and other concurrent or future contracts wherever it is desirable and appropriate.
- e. Receive performance reports submitted by the contractor and verify their validity and accuracy.
- f. Evaluate the contractor's progress and reward him for any amounts earned (under the award fee or incentive provision).

12. Additional effort may require additional cost incurrence. Several types of additional costs that may be incurred in implementing MIP's and their reporting systems are discussed below:

- a. The costs of establishing, conducting and implementing a MIP. Such costs will generally be recovered through overhead.
- b. The cost attributable to submitting reports to the Government as required by the instant (or any given) contract. These

should be solicited, proposed, and contractually covered via DD Form 1423, Contract Data Requirements List. Such costs should be negotiated to reflect only the administrative costs of the reports, and funded by the instant contract appropriation.

13. Any plan as innovative as the Should-Cost MIP concept will entail risks. The following factors touch upon some of the apparent hazards and areas of caution:

a. The quality of a MIP will be no greater than the quality of the Should-Cost analysis. If the Should-Cost output is shoddy, it is unrealistic to expect that the resulting MIP will accomplish any real improvements in cost efficiency. Almost certainly, most contractors would recognize and reject recommendations that were ill-founded, and thereby weaken the Government's negotiation position. The extent of such a risk hinges upon the quality of the Should-Cost team's findings and recommendations, their perceptiveness, and their ability to identify reality and responsiveness both during the initial analysis and during the MIP progress verification process, and serves as another reminder that the most important watchword in Should-Cost is quality.

b. A contractor may "agree" to a MIP with little or no intention of actively striving for improvements because of ineffective incentives or unrealistic goals.

c. A MIP reporting system will, of necessity, call for submission of cost data and internal management and operational

information. Such data should certainly be subject to verification and audit. In a fixed price environment, however, a contractor may not agree to disclose such data in any way other than as required by law, such as PL 87-653. There is, therefore, a risk that the Government might not be able to obtain full visibility of the contractor's responsiveness to the MIP, unless the point is fully covered in the Memorandum of Agreement.

IV. Should-Cost Negotiations

1. It is established policy, in AMCR 715-92, Should-Cost Analysis, that the team chief will also serve as the principal contract negotiator, and therefore, that only people with proven negotiation abilities will be nominated for team chief positions in Should-Cost analyses. For this reason, it is not necessary for the Guide to cover principles of negotiation, except for aspects peculiar to the Should-Cost environment. However, for the benefit of those who desire to "brush up" on the art and techniques of negotiation, the following books may be consulted:

- a. Department of the Army Field Manual 38-33, Logistics Procurement Management Negotiation;
- b. The Art of Negotiation by Gordon W. Rule;
- c. The Art of Negotiating by Gerald I. Nierenberg;
- d. The Negotiating Game by Chester L. Karass.

Additionally, the negotiator may find it helpful to review the section on "objectives" in the ASPR Manual for Contract Pricing (ASPM No. 1), pages 13-6 to 13-9, a copy of which is in the Should-Cost Library.

2. It is important that the team chief be able to negotiate in a logical manner. Consequently, the analysis of cost elements should indicate alternatives, where appropriate, to enable the negotiator to establish a range about the objective.

3. Because of the depth of the analysis, and the extent of its coordination, the team chief, as principal negotiator, will have far more knowledge of the contract effort than usual. This should provide him with more-than-usual confidence in the strength of his position, enabling him to bargain more effectively. Past experience has shown that the government negotiator sometimes becomes even more knowledgeable than the contractor, concerning key areas.

4. The analyses of the individual cost elements should reflect the underlying reasons for the differences between the contractor's proposal and the Should-Cost position. The negotiator should be able to classify these differences in the following manner:

a. Supportable exclusions, i.e., adjustments to which agreement is virtually automatic, such as errors, duplicate charges, unallowable costs, etc.

b. Unsupportable inclusions, i.e., amounts associated with biases, contingencies for uncertainties, faulty estimates, etc., which cannot be supported by factual data.

c. Inefficient and uneconomical practices.

5. If possible, the negotiator should attempt to categorize any

changes in the contractor's and Government's pricing positions into these areas. This will enable him to better assess the significance of price movements occurring during negotiations and the relative impact of concessions made by each side.

6. As described in the previous section on Management Improvement Programs, the Should-Cost negotiator's attunement goes far beyond just the instant contract--he must think of the contractor's total operation, in terms of its impact on other Government work being performed concurrently and/or subsequently.

7. The Should-Cost negotiator should recognize that there is a high level of command interest in his negotiations. This may be useful to him in helping to resolve long-standing problems of real significance. There have been many instances in which Should-Cost negotiations have provided the necessary degree of emphasis to change unsatisfactory conditions that have existed for many years.